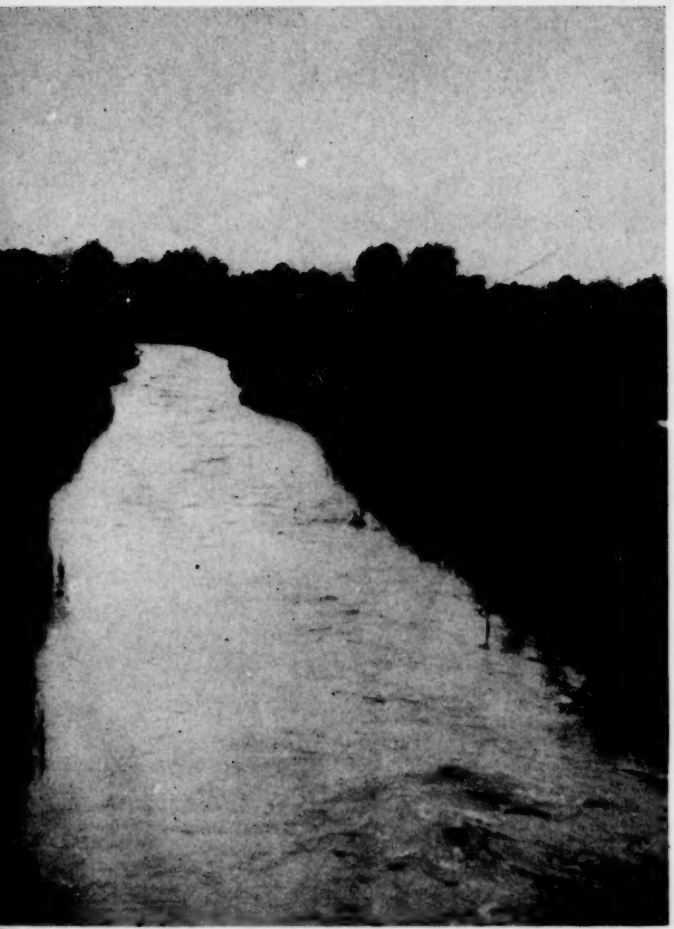

Volume 6, No. 1 **January 1951**

Conservation: A Social and Moral Problem

Structure and Sandy Soils

On Water Resources

Winter Aspects of Soil Structure

Wood Chips, Water and Soil

Keeping the Dust Under Cover

Utilization of Natural Underground Water Storage Reservoirs

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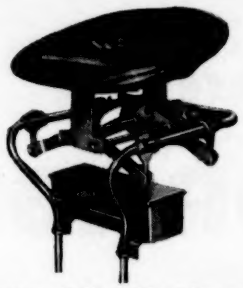

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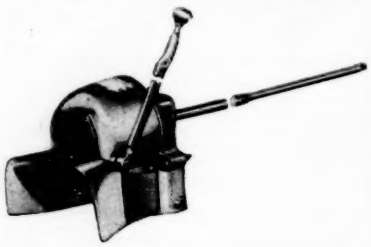

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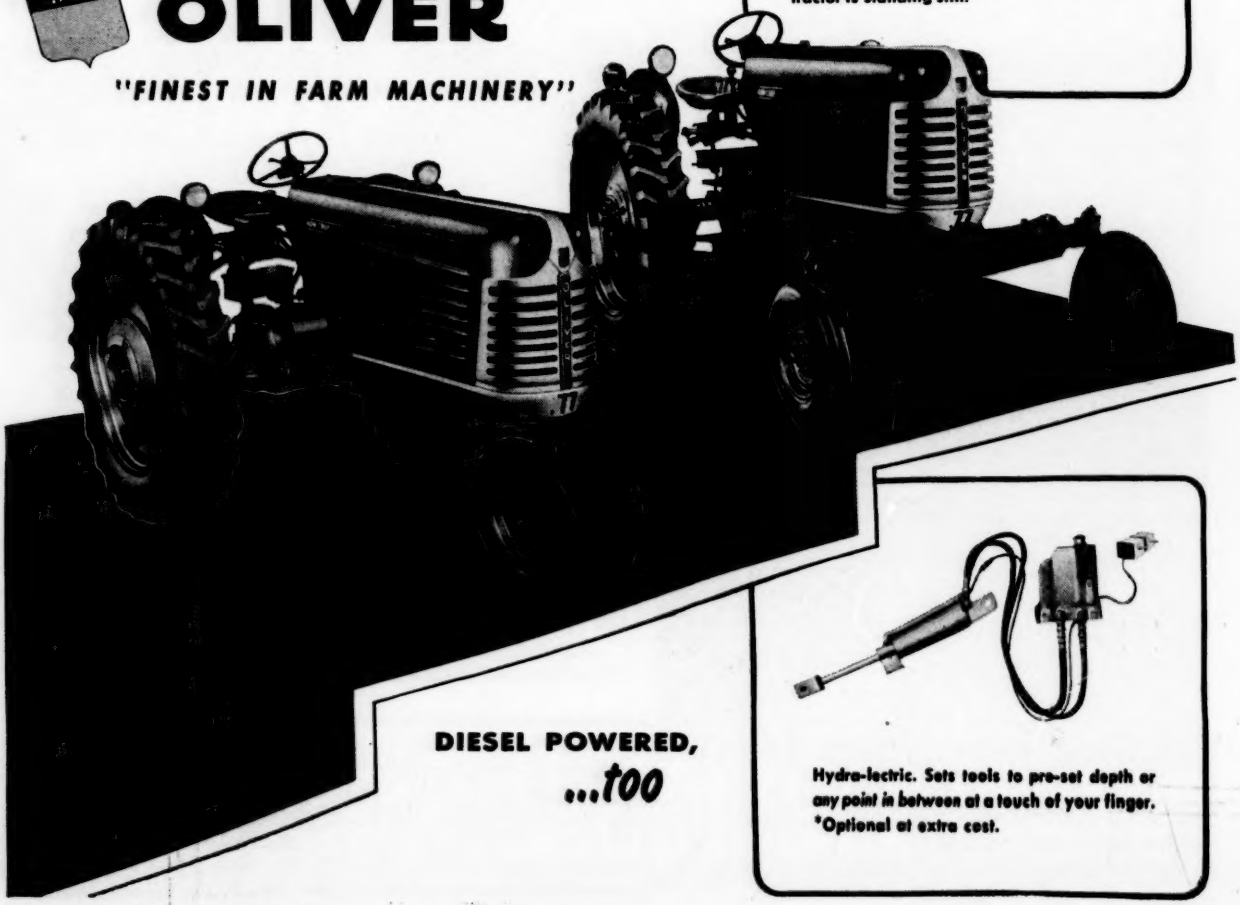

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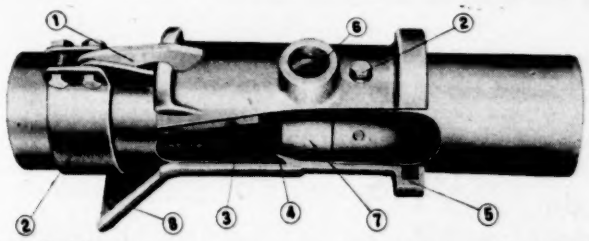

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Journal of SOIL AND WATER CONSERVATION

VOLUME 6
NUMBER 1

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COVER. The waterway shown in this photograph taken in Montgomery County, Tennessee, is part of a drainage system approximately two miles long. It drains a watershed of 500 acres. Two weeks of heavy rains caused the waterway to carry a continuous flow with no apparent damage. The water shown in the photograph is about three feet deep and 20 feet wide.

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These are the seven magic words which have sparked a crusade the length and breadth of agricultural America.

They express the basic doctrines of a new and broader concept of farming *and living*. Known as "Animal Agriculture", it forms the basis for a national farm and food program designed to build the fertility of our farms, and give to America and the world a new measure of freedom and abundance.

No greater tribute can be paid the late H. E. Babcock, father of the idea, than the present wide adoption of this program which he so vigorously and successfully advanced.

Next April a National Animal Agricultural Institute meeting will be held at Purdue University to train selected leaders in a complete understanding of this far reaching idea; also ways and means will be developed to follow through with this nationally important program in the months and years ahead.

As one of the divisions of the AVCO Manufacturing Corporation, we are happy to sponsor this dynamic idea initiated by our former associate, Ed Babcock. And we take pride in the fact that our adoption of this three-pointed Animal Agriculture program dates back to the time of its inception.

NEW IDEA

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A Platform and Preliminary Plan of Action for the

Scientific Use and Development of Natural Resources

There is today a growing awareness of the fact that land, water, the living resources, and man are intimately related. Resource management must be considered not only in its separate categories, but in its entirety. It is time for the adoption of a national policy on natural resources. Agreement on such an objective will lend force to the successful prosecution of a broad resource-use program, and strengthen the support given to each resource. With these conditions in mind, a majority of the member organizations of the Natural Resources Council of America adopted the following platform and preliminary plan of action on October 2, 1950.

A Land and Water Policy

Principle: Adoption of a national policy by the Congress of the United States to secure in the public interest the maximum benefits from the nation's land, water, and related natural resources.

Action: Cooperate in the preparation of a comprehensive statement and policy designed to insure the permanent wise use of land, water, and related resources and the preservation of natural park and wilderness areas.

An Appraisal

Principle: Adequate inventory of the land and water resources of the nation to determine their condition, productivity, and potential use in relation to a priority of human needs.

Action: Support current inventories of all land, forest, water, range, and wildlife resources as the proper guide to the utilization and treatment of these resources; and develop other inventories where need is demonstrated in the public interest.

A Goal

Principle: Achieve unified scientific management and perpetuation of land, water, and the living resources in the widest public interest.

Action: Support the rapid development and application of a comprehensive scientific conservation plan for every unit of the nation's land and water; such plans to be appropriately coordinated with watershed protection and other programs designed for wise resource use and perpetuation.

A Method

Principle: Strengthen individual and group responsibility and participation in the planning and effectuating of conservation activities.

Action: Give continuous support to sound conservation programs on all public and private lands, and as a primary step, encourage the organization and development of soil conservation districts throughout the nation and urge widespread assistance to such districts.

A Motive Power

Principle: Economic, social, and cultural stability of the nation depends on scientific management and use of natural resources in the public interest.

Action: Promote educational programs designed to develop and perpetuate the concept of conservation to the end that all may share in putting them into effect and in enjoying the resulting benefits.

First draft of the above statement originated in meetings initiated early in 1950 by the Soil Conservation Society of America. It was adopted in its present form by a majority of the member organizations of the Natural Resources Council of America in which the Society holds membership. The Council is made up of some 35 national member organizations active in the conservation of renewable natural resources. It includes conservation associations as well as scientific and professional societies. The role of the Council is that of a service agency to its member organizations. It does not undertake to control the policies or actions of its members and does no lobbying.

As a step toward the formulation of a land and water policy for the nation, the Soil Conservation Society of America adopted at its Third Annual Meeting in Cincinnati, December, 1948, a NATIONAL LAND POLICY, which was published in the January 1949 number of this JOURNAL.

Conservation: A Social and Moral Problem

CARL C. TAYLOR

Moral sentiments in all history, says Dr. Taylor in this article, have been the product of group necessity and the acceptance of group responsibilities. Conservation of our resources will not be recognized as a moral problem by any other process. Students of natural resources and human relations must make the necessities of conservation widely known. This also applies to religious leaders, scientists, and statesmen who must join hands in making individuals, groups and governments willing to assume responsibilities for promoting and, if necessary, enforcing responsibilities.

"MANKIND SURVIVED TENS of thousands of years without facing a series of conservation problems," said Dr. Julian Stewart, Head of the Department of Anthropology, Columbia University, at the Inter-American Soil Conservation Conference at Denver in 1948. He added that "until the European Conquest, land use tended to conserve rather than destroy resources." In this article it is my purpose to attempt to do a very simple yet a very difficult thing, viz.: first, *describe why and how those countless generations of men to whom Dr. Stewart referred conserved their natural resources; second, analyze the moral imperatives which controlled their behavior; and third, say something about the issues and problems of developing moral imperatives which will today and in the future cause us to conserve our natural resources.*

Plato asserted that "no group, even the most antisocial, can exist without a minimum of morality necessary for its survival." Darwin, a biologist who spent his life studying lower organisms than man said he discovered mutual aid everywhere in the struggle for existence. He imputed this to what he called "social instincts." Morals, however, are not instincts which can be biologically inherited; they are human sentiments which must be individually learned and socially enforced. Morals (the mores) are developed by all groups and societies to sustain what each society believes is right and good. The most stern morals of all groups and societies have been, and are, those which safeguard and promote the survival of the group.

If we and other peoples are today destroying the resources upon which our survival depends, it is either because we do not know that our survival depends on them or because we have not developed social and individual sentiments which have risen to the level of moral imperatives. Simple, so called "primitive," groups did know that the resources under their control were limited and that they had to conserve them or die. They therefore developed deep moral convictions about conservation and passed these mores on to each succeeding generation. Dr. Stewart said "disregard for the future is a comparatively recent phenomenon." We seem to have developed this disregard in a big way, but I am convinced that it is not because we are inherently less moral than primitive man. It is because our human relations are so complex that we don't really know all we should about them. Morals are the cement of group life and we have difficulty in creating this cement because we aren't intelligently conscious of all the groups to which we belong. We can't develop moral imperatives about our group problems until we develop social sentiments within these groups and we won't develop these sentiments until we become aware that we are members of groups which are far greater than those in which we participate in a face-to-face fashion.

Once simple societies had established their moral imperatives they enforced them by sanctions and taboos. They didn't have to depend much on laws because each individual believed that to violate a taboo was an unpardonable sin. Rivers says, "among such people as the Melanesians there is a group sentiment which makes unnecessary any social machinery for exercising authority." Another anthropologist tells of seeing a Copper Eskimo, who because he was ill, felt sure he had unknowingly violated a taboo. He went to the Medicine Man who worked over him for two days to help him get right with his own conscience.

The Iroquois Indians depended heavily on fish as a part of their food supply and they guarded this natural resource by a taboo against fishing during the spawning season. The individual Iroquois believed if he violated

---

Dr. Carl C. Taylor presented this paper at the annual meeting of the Soil Conservation Society of America held in Detroit, October 26-28, 1950. He is Head of the Division of Farm Population and Rural Life, Bureau of Agricultural Economics, with headquarters in Washington, D. C. Dr. Taylor is the author of many manuscripts and bulletins on farm population and rural life. He is also a co-author of *Rural Life in the United States* published in 1950 by Alfred A. Knopf, New York.

this taboo that Orenda, the Spirit of the Great Wacunda, would strike him dead or bring some dire thing into his life. We call such beliefs superstitious, and so they were, but the point is that they worked because they were group moral imperatives and as such were a part of the conscience of each individual member of the group.

Taboos and sanctions were supposed to identify those objects and those types of behavior which were good or bad. The most universal ones had to do with the conservation of the natural resources upon which the physical survival of groups depended. Others sought to perpetuate the integrity, or wholeness, of the individual groups. Their methods of enforcing their moral imperatives were cruel but they nevertheless converted their beliefs into religious doctrines and their practices into religious rites the better and surer to preserve them. In order to preserve the known natural resources upon which their survival depended, they practiced infanticide. They allowed their aged to die or be destroyed when they could no longer contribute to group survival. In the most dire situations, they ate their own parents and believed that neither their parents nor they could go into the Great Beyond unless they did eat them. Crude as such things were, they had to do with the necessities of group survival and therefore became part of the moral imperatives of their groups, which no one violated. As the organization of simple societies rose above the level of primitive communism, in which there were no specialized functions and few if any specialized obligations, the first step in the direction of what now prevails universally in modern society was the gradual appearance of specialists. The first specialists to arise were the religious leaders, medicine men, and priests. They had two basic functions; one was to be the keepers and the teachers of the mores and the other was to be liaison between their people and the Spirits. As keepers and teachers of the mores, they passed the moral imperatives of their group down from generation to generation. Acting as liaison between the people and the Spirits, they interpreted to their people what the Spirits desired, and they were believed to be on good enough terms with the Spirits to influence them on behalf of their people.

Again we say such beliefs are superstitious. Sure they are but they worked and all I am saying is that by discovering on what basic issues of life people over long periods of time have developed their moral imperatives and by learing how deeply they have been convinced that both group survival and group integrity depended on the maintenance of these moral imperatives, will help us more clearly to see our own situations and responsibilities. We are not going to turn back the direction evolution has traveled from the ways of primitive to the ways of our secular society. But it is my belief that some guideposts for underwriting our secular behavior with moral imperatives can be visioned by finding answers to the question of how the sure moral imperatives, which at one time existed, were diluted during that evolution. I believe the first step in that dilution came when social contacts were extended beyond the boundaries of face-to-face groups and thus included strangers. A stranger was not a real person because he was not a member of one's own group. The second step was the development of money economy, ultimately applied to natural resources as well as trade. When land was alienated from group ownership and became an individually merchantable good, the value of land was no longer measured by group survival values but by money values. The third step was the development of specialization, i.e., the individualization of personal functioning, in which the value of each person was measured in terms of his individual talents and not in terms of good group membership. All of these were steps in the long evolution of the secularization of human relations and the consequent dilution of the individual's group responsibility.

New specialists in trading, a merchant class, early came into existence whose members did not live directly from the land. Farm products to them were not the fruits of natural resources; they were merchandise. Under the impact of a developing commercial economy, ownership of land and other natural resources were alienated from group ownership and came to be exploited as private enterprises. The Aztecs went only part way in this direction. They allotted lands to individuals but took them away at the end of two years if the lands were not properly handled. In deep peasantry the land is individually ofned but it is "not for sale" because it must, by their mores, be passed on to the next generations. As a family inheritance, it isn't exploited, but conserved. The greatest deterioration of natural resources has not occurred and is not occurring where traditions of this type prevail. It isn't occurring where groups of people must still live on limited resources. It is occurring where individual entrepreneurs don't recognize the life and death struggle between group survival and resource depletion.

A number of peoples are today in the process of these transitions. Guatemalan Indians who lived for hundreds of years in their self-sufficient villages are entering the marketing economy. Soil erosion is probably traveling fifty times faster because they are pushing production for market sales. The same thing happened all over the world. It was not primitive men who destroyed the ancient civilizations but men and societies who came on

the scene after primitive societies with their stern conservation mores and before modern men and societies had developed a conservation conscience.

Our own history of handling our natural resources is the best laboratory in the world to study and discover what happens when the transitions which I have been discussing take place rapidly. It was not only by design but by fortuitous good fortune that in the settlement of this continent our forefathers broke almost completely with the traditions and social controls of older civilizations. They were escaping from the tyrannies of such controls and they fell heir to the most giant body of undeveloped natural resources in the world. It was an historic accident that the settlement of our lands and the exploitation of our natural resources was coincident with the development of the Industrial Revolution. Trade and commerce opened the markets of the world for the products of our natural resources and the opportunities of our vast frontiers invited men with inititative and enterprise to exploit these resources.

In this miraculous development we demonstrated what we thought were the successful ways of life and naturally built creeds to buttress and promote that way of life. It is easy to understand why we built and believed in these creeds. For three hundred years we developed by expansion of our frontiers. We discovered and exploited unheard of natural resources. We found these resources by trial, error, and success methods; took chances, knowing that if a man missed the first time and at the first place there were plenty of opportunities to try again. Some speculation was necessary under the circumstances and for 300 years such speculation paid off in a big way. Thus *Expansion, Exploitation,* and *Speculation* almost automatically became our creeds.

Out of these experiences and developments we built the strongest and freest Nation on earth, but today we are raising questions. We are asking whether the experiences of building America were not so abnormal (super-normal) that they cannot be the pattern for all places and peoples of the earth, or even for our own future. We are asking whether our creeds of *expansion, exploitation,* and *speculation* will work as well in our maturity as they did while we were in the process of growing up. There is some evidence that we are even beginning to answer these questions by saying that we are now trying to develop both the technique and creeds of *conservation* and *security.* If this be true then we can utilize the lessons from history of how peoples of the past moral sentiments to buttress and promote their beliefs and practices.

The development of moral sentiments is more difficult in a highly complex and impersonal society than in simple face-to-face groups, but the same basic principles apply to both. As simply stated as possible the principles are: (1) *All groups must have morals (mores) in order to survive as groups.* (2) *The morals are automatically maintained and sustained when and where the personal consciences of the members of the groups are the same as the mores of the group.* (3) *Penalties are assessed against, or other group controls are exercised over, those members of the group who violate the group's morals.*

But the application of these principles is difficult in a big complex impersonal society. Human relations are so atomized that they become secular, not sacred as they are in family life, and as they were in whole groups of simple societies. Today we are members of groups that are so large that we don't understand, or even know, all the relationships in which we are involved. We are members of a great many groups, some of them groups within groups, and our group loyalties sometimes conflict with the others. Primitive groups were not involved in these difficulties. Every one knew every one else, knew in what ways his behavior affected all others and the ways others' behavior affected him. Because of this intimacy it was not too difficult to develop moral sentiments about all these relations and not too difficult for the group to enforce the moral codes which these sentiments dictated.

Moral sentiments in all history have been the product of group necessity and the acceptance of group responsibilities. It cannot and will not be different in the future. The conservation of our natural resources will not be recognized as a moral problem by any other process. *Those of us who are students of natural resources and those of us who are students of human relations must join hands in making the necessities of conservation widely known. Religious leaders, scientists, and statesmen must join hands in making individuals, groups, and governments willing to assume responsibilities for promoting and, if necessary, enforcing responsibilities.* No matter how many or how complex the human relations men now have, they must understand them and be willing to share the responsibilities which they involve. Only thus can they be intelligently moral because only thus can they know how to be moral. *The need is not only for scientific knowledge but conscience, not only for reason but for sentiment.* Only when men by the millions become rationally conscientious about the basic issues of human survival will such giant problems as conservation be solved by moral principles.

If the problem of survival is even in part the problem of conservation, then conservation is a moral problem. The issue is how can we make men by the millions conscious of and concerned about this fact. We can't do

(*Continued on page* 14)

On Water Resources

MORRIS LLEWELLYN COOKE

The biggest single problem immediately ahead, says Mr. Cooke, is to devise practical ways and means of putting scientific knowledge to work much faster over a larger area. To accomplish this, we need to develop new and acceptable refinements to our social and political institutions that will not only sustain our land and water resources, but strengthen democracy in the process. There is no organization in a better position to provide a large share of the necessary new ideas and new concpts than the Soil Conservation Society of America.

THIS MEETING COMES at an opportune time. Our country is in the process of mobilizing its resources once again. Across the ocean, our military forces are in action for the United States and the United Nations. At home we are rebuilding our military strength and developing our economic defenses against any new agression that may threaten peace at home or the peace of the world.

No one knows how long the present emergency will last. From all the signs, it may last a long time. Indeed, on the basis of what is now going on in the world, we would be foolish to gamble otherwise. We have no alternative, as I see the situation, but to make promptly all necessary preparations for a long-drawn-out period of strain and crisis. Under these circumstances, professional soil and water conservationists have a big job cut out for them. In every war—whether it is a cold war, a warm one, or a full-scale shooting war—the price in natural resources we needs must pay is great. We are forced to use our resources more intensively and experience shows that on occasion we use them recklessly. Many of our minerals are approaching exhaustion, the very soil itself is abused and allowed to slip down the slopes at an accelerated rate, for practical purposes forever destroying any future contribution it may make to our well-being.

There may have been a time in our history when we could afford to be reckless with our resources, but that time is certainly past. Now our luxury margin is gone and we must be far more careful in our use of what remains. Water, land, and their related resources are vital elements in the building and maintenance of a strong nation. They may be critical elements in national defense. Under these circumstances, it becomes increasingly clear that we need new and better techniques for using these resources competently, year after year, under the pressures of the world in which we live.

The Prospects of Resource Strain

If anyone doubts the need, consider some of the prospects facing us as a nation. We are likely to have nearly full employment, accompanied by relatively high prices and high wages, for many years to come. Our material standard of living is steadily rising. Our military forces are acquiring new and elaborate equipment. We shall probably undertake to provide aid of various kinds to our friends in the United Nations, although at this stage one can only guess at the full extent of our future foreign assistance.

There is little guess-work involved, however, in deciding what this situation means to us in terms of natural resources. The combined civilian and governmental purchasing power of a nation bearing the brunt of widespread and heavy international obligations promises to put a strain on our natural resources that may be prolonged for generations.

While this probability encompasses all natural resources, I am speaking here particularly of land, water, and such related resources as timber, grass, fish and wildlife. With each passing year, as I see it, we will have to give more and better attention to the underground water supplies of California and New Jersey, the productive farmlands of Ohio and Iowa, the timber of Oregon and Georgia, and the grasslands of Colorado and Texas. The States I name are only illustrative, of course, of nation-wide needs.

In recent years we achieved productivity levels on our farm and range lands about a fourth above those prior to 1940. Better machinery and equipment, improved plant varieties, better insecticides and fungicides, sharply increased use of fertilizers, and generally good weather all contributed to production records. But we also used our land more intensively. Many thousands of acres were used far beyond their normal capabilities and their

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Morris L. Cooke has been active in the conservation movement for many years. He is at present Chairman of the President's Water Resources Commission which recently issued the first section of its report.

Mr. Cooke delivered this paper at the annual meeting of the Soil Conservation Society of America held in Detroit, October 26-28, 1950. A small section of the paper, because of its length, was deleted.

productive capacity has been seriously damaged. On such land, high production will be more difficult and more costly for many years to come. This is a plain case of over-use and waste. If we hope to avoid such mistakes and maintain the new high levels in the future, it becomes imperative that we speed up the *rate* of conservation work to insure first of all that our physical soil body remains in place. As soon as possible, we need to help farmers and ranchers put each acre of land to the use for which it is best suited, and also apply the right combination of conservation measures to each acre in accordance with its need for protection under such use.

From the standpoint of gaining the ultimate from our lands for the long as well as the short pull there are many hundreds of thousands of acres now being used unwisely for clean-tilled crops which should be taken out of cultivation and used less intensively for grass and trees. Other thousands of acres, now in grass and trees, are suitable for cultivation and could be used safely for row crop production. There are millions of acres now being used within their capabilities, but without protection against erosion or other forms of land damage. They will continue to lose productive capacity until they are given thorough conservation treatment. All these lands, of course, are not in equal need of treatment. Some are being eroded at a much more rapid rate than others. On these lands the need for conservation work is critical and they should have it first. Meanwhile, however, we cannot afford to slow down the conservation work on lands being damaged at moderate or slow rates. We need *all* of our productive land and we need it in the best possible condition.

We also need to give more thought to fish and wildlife, and recognize more widely their value both to our food supply and recreation.

Sequence of Erosion and River Sediment

Until recent years, very few people were concerned about the sediment piling up behind our dams and in the deltas. Now there are many more people who recognize how the sequence of farmland erosion and reservoir sediment threatens our future storage supplies of water for industry, power, irrigation, and for municipal water supply.

Floods from eroding lands, which draw the headlines when they damage our urban areas, are even more ruinous to our rural productive resources. Each succeeding flood further saps our national strength.

We have great agricultural development opportunities in irrigation and drainage, as well as in the conservation and wiser use of existing farm and range lands. I dare say we have not yet begun, as a nation, to capitalize on our opportunities for wildlife and forest development.

And lest some may overlook it, we also need to remind ourselves that natural recreational areas not too remote from our great industrial centers become doubly important to workers laboring in a troubled world.

All these and many other factors were in my mind when I said, at the beginning of my remarks here, that this meeting comes at an opportune time. You are unquestionably the nation's leaders in soil and water conservation thought and action, especially on agricultural lands. You are the professionals in the field—the men and women that millions of people in the United States are counting on to give them guidance in what should be done to maintain our resources in the best possible condition, for the greatest good, to the greatest number and for as long as may be necessary.

A Test for the Profession

I assume that some time during the course of this meeting many of you will be putting your minds to the greatest single job ahead of you—the development of ways and means whereby you can fit your work into the larger framework of national mobilization and the nation's urgent needs. I can assure you that this is no academic problem. It is real and here right now. It is a problem to test the ingenuity and ability of your entire profession.

Let me ask each of you a question: What would be the position of our nation in the seventh year of a cold war, or a hot one, if by the end of the fifth or sixth year we have ruined large areas of land, sapped the nation of its productive capacity and failed to provide adequately for our water needs?

The work for soil and water conservation has progressed by leaps and bounds in the past 15 years and for that very reason we must all be on guard against complacency. This profession, too, must be awake to the perils of "too little and too late." Now, again, we have reached a time for bold thinking and resourceful leadership.

Many years ago, under different circumstances, a distinguished American philosopher set down words which are appropriate here, today.

"The human race now passes through one of its great crises," he wrote. "New ideas, new issues—a new call for men to carry on the work of righteousness, of charity, of courage, of patience, and of loyalty—all these things have come and are daily coming to you. . . ."

This is today's challenge to you and to me!

American society has tended increasingly to specialization. In many repects this has been useful. But at the same time each specialist has an obligation and a responsibility to recognize at all times how his work fits into the larger, total job. Each man's work is, or should be, a contribution to the progress of our country and to

the advancement of our society and culture. And what is true of the individual specialist is equally true of organized groups of specialists.

You already have a very large amount of knowledge and experience in the conservation, improved use, and development of land and water resources on farms, ranches, public domain, soil conservation districts, and forests. You are now working in a number of watersheds on the "upstream engineering" phases of flood control. The ultimate success of all this work, however, will be measured by the degree to which it contributes to our larger objectives as a nation of free and aspiring people.

A similar test is confronting the President's Water Resources Policy Commission. We are now completing an assignment which we sincerely hope will be useful to the nation as a guide to the wise and more orderly development of the tremendous values inherent in our great river basins. We are recognizing the intricate relationships of water, land, related resources, and those dependent facilities and considerations such as recreation, hydroelectric power, and the preservation of strong local institutions. It is my personal hope that what is now being done on many small watersheds can be expanded, improved, and supplemented on the larger scale possible in river basins. But whether resource work is carried forward on a small or large scale, the final test of its wisdom in our country lies in the manner and degree of its contribution to the general welfare.

The Weapons Against Resource Pressure

If we can plan carefully and exercise foresight, who will say that we cannot sustain our resources under the pressure of record use and record production for all the years ahead? Unless we are complacent or excessively timid, we should even find it possible to build up our resources and expand their usefulness.

I believe a great many Americans are not only ready but eager to see a comprehensive proposal for the conservation, use, and development of land, water, and the related resources. This was not always the case. We can all remember, I suppose, when most people took these resources for granted. I can assure you, however, the national attitude has already changed considerably, and is continuing to change for the better all the time. Today, there is a wide and genuine recognition of the fundamental value of land and water resources. Many of you here this morning have had a large part in that accomplishment.

Shortly after the President's Water Resources Policy Commission was established, we decided to seek the views of all the individuals, agencies of government, commercial and educational institutions, and other organizations that held any promise of helpful contribution to our assignment. The way in which this was done has been covered in an article entitled "Reports and Comments," by Dr. R. R. Renne, which was published in a recent issue of Land Economics. I also covered this subject in an address before the Pennsylvania Water Works Association in Atlantic City on the 27th of last month.

Very little has been said or written, however, on the response the Commission has had from these inquiries. It would be impossible to evaluate the time and thought which must have gone into the preparation of replies, ranging from two and three page letters to elaborate reports, all for our information and guidance.

Confidence—Inspiring Public Expression

The great bulk of this material, running into tens of thousands of pages, has reflected the deep interest in land and water resources which is entertained by people in all walks of American life. Moreover, it is confidence-inspiring to realize that almost all of this expressed opinion seems to grow out of sincerely held views and a deep-rooted love of country.

You will be pleased to hear that in this large volume of opinion, there has been only a trace of thinking which appears dictated by narrow, special-interest considerations. Naturally, on some of the issues inherent to our task, there has been a wide difference of opinion. On the other hand, there has been surprising unanimity on some points upon which we are forced to reach decisions. The whole experience has left this member of the commission with a strong feeling that the people of the United States intend to see questions affecting the conservation and wise use of our resources settled and settled right.

Make no mistake about one thing. There is no evidence of a lack of interest!

Public Awareness of Water Problems

The people of this country, through their representative institutions and organizations, are surprisingly well-informed about the mounting demands of the country for water. They are generally aware that industry, big cities, and many of the facilities of modern life are using vastly increased amounts of water. They recognize that our population is increasing and that agriculture is also using more water. They have noticed that soil erosion aggravates the water problem in many ways. They have either experienced actual water shortage or read about it. They don't like water shortages and I would say

there is a prevailing opinion that we can eliminate shortages, if we will only go to work on the job.

Of course, there is wide variety in the recommendations about the ways in which we ought to tackle the problem. I am not going to review them now because I imagine this audience is only too well aware of the diverse points of view. However, at the risk of summarizing what may be old information to many of you, I am going to review some of the elementary facts about our water resources.

First, there is no evidence of any substantial change in the total amount of water available to us, on the average, over the years.

There is ample evidence that our total use or consumption of water is increasing steadily and will probably continue upward.

There is ample evidence to prove that as a nation we are wasting vast amounts of water.

No "National Water Shortage"

Some localities in our country are troubled by too much water; other localities are being faced with increasingly grave shortages. In virtually every locality that has a water problem, it is a local problem, caused either by local overuse or misuse or failure to anticipate the requirements and provide for them adequately. Frequently both causes exist. Talk of a "national water shortage," and a "declining national water table" serves only to confuse our problem. We do not have a "national water shortage" and there is no such thing as a "national water table." Yet in a number of individual areas throughout the United States, the supply of water is most certainly becoming scarce and the ground water table is most certainly sinking. In such cases further development in municipal growth, in industrial growth, and in population growth is limited unless water supplies are imported, and all economies in the use of water are practiced.

There is reason to believe that most of the existing shortages can ultimately be corrected, although in some cases the corrective measures will have to be either expensive or drastic, or both. Some movements of population seem inevitable.

In very few places throughout the country can it be said that we are taking full advantage of available water supplies and reducing needless loss and waste to a minimum.

It now seems apparent that we have neglected our water resources for so many years, and especially our watersheds and water storage facilities, that we have an almost phenomenal amount of catching-up to do. As a general rule, we have not anticipated our needs accurately. In many localities, surface storage facilities are either inadequate for present and prospective needs, or will soon become inadequate as a result of excessive reservoir silting. We have not provided adequately for the recharge and management of ground water supplies. We have permitted pollution, even in areas of limited supply. Almost nowhere have we given watersheds the over-all consideration and treatment they deserve in view of their importance to our whole water situation.

Water Is a Complex Resource

Too often and in too many places we have apparently regarded water as a single or an independent resource, and tried to deal with it on that basis. Yet the supply is irrevocably related in the vast majority of circumstances with land, crops, forests, grass, wildlife, and such man-made alterations to the landscape as cities and highways.

I believe it is correct to say that until very recently we failed to see our water situation in its totality and that is the only way to treat it. It may be that specialization cut into our breadth of vision. We have at various times and various places attempted to deal with water pollution — as a single problem; flood control — as a single problem; and soil conservation — as a single problem. We have attempted irrigation, drainage, hydroelectric power development, construction of surface storage facilities, improvement of navigation, and a host of other water developments — as single problems.

For all practical purposes, it is a denial of Nature to regard water or any of the developments normally associated with water as single problems. Water is one part of the great complex we call Nature. When we make an alteration in any one part, we automatically alter in some degree all the other parts. I know that this interrelationship of land, water and their dependent resources is well known to you, but it is sufficiently fundamental to bear repeating over and over again. Just as we can look so closely at the trees that we cannot see the forest, so we look so closely at the gallons, acre-feet, kilowatts, and bushels that we cannot see the watershed.

Water deserves the big look. It deserves big thinking. And in my opinion there is no organization in a better position to provide a large share of the necessary new ideas and new concepts than this one.

Wider Use for Our "Know-How"

We can recognize, I believe, that at least a large part of the physical technology needed for the conservation, wise use, and development of land and water resources

is known. I do not mean to indicate that we know all the answers to all the technical problems, or that we no longer have need for research. I doubt whether we shall ever be completely satisfied with the extent and quality of our knowledge. But I think it is fair to say that we already have enough scientific "know-how" in this field to bring about a monumental improvement over existing conditions, if we could only learn how to use it on a sufficiently broad scale.

Professional soil and water conservationists, I am told, have always prided themselves on their achievement in bringing a large number of the natural sciences to bear, in a coordinated way, on our land and water problems. I have personally seen some of the evidence of your success in this direction. I have seen areas where engineering, agronomy, forestry, biology, hydrology, and probably other sciences have been harmoniously employed together with excellent results. But everyone admits we are not moving ahead fast enough to meet prevailing needs.

Under these circumstances, it seems to me the assignment is clear enough. The biggest single problem immediately ahead is to devise practical ways and means of putting your scientific knowledge to work much faster, over a much larger area, and thereby make it more serviceable to all concerned. In your early days, you set out to align all the appropriate physical and biological sciences in support of your cause. The present situation suggests that you now take the next step and incorporate the social and political sciences. In my opinion it is not any lack of technical "know-how" which is standing as the principal barrier to the rapid spread of your work, but insufficient development of the social and political techniques and associations that are so vital to widespread action in a democratic nation.

Democracy Is Not Automatic

Our country, we can be thankful, is not a dictatorship. There is no man in Washington who can order all the people to apply our modern conservation measures. Here we have a form of representative self-government for which Americans have worked and fought since colonial days. Our government is founded on the premise that we have the spirit and the ability to decide for ourselves the actions we want to take together in our joint interest and common welfare. It is the kind of society that we believe offers the greatest advantages in personal liberty and the greatest opportunities for accomplishment. At the same time, I trust we all recognize that nothing in a democracy is automatic. We must work with it and for it unceasingly to keep it modern and dynamic. As our society grows more complex and new problems develop, we must apply ourselves always to the task of social and political refinements that will meet our needs without jeopardizing in any way the fundamental principle of representative self government. Indeed, *the test of a vigorous democracy lies not alone in whether it can preserve self-government in the face of new national problems, but whether in the solving of these problems it can actually strengthen its basic principles and institutions.*

The Great Duty of Conservationists

One sure way to bring about dictatorship is to allow our land and water resources to diminish to the point that only by rigid control and despotic management may we sustain ourselves. With this background I say that *our great duty is to develop new and acceptable refinements to our social and political institutions that will not only sustain our land and water resources, but strengthen democracy in the process.*

It seems to me the attitude of most Americans is now especially favorable to such a line of thought. The needs are more apparent than ever before. And not since the soil conservation district concept was launched on its remarkable course almost 15 years ago has there been an advance of comparable magnitude in the natural resource field. It would seem the time is ripe for the next great steps.

Conservation: A Social, Moral Problem

(*Continued from page 9*)

it by passing resolutions. Moral sentiments in all history have been the product of recognized necessity and the acceptance of group responsibility. It cannot and will not be different with conservation. The task no matter how difficult dare not violate the principles of which all through this article I have been giving illustrations. Morals don't arise in a complex society such as ours by superstition and are not enforced by ignorant medicine men. They arise by such processes as I described in my article on Conservation as A Movement. (*Journal of Soil and Water Conservation Volume 5, No. 3*) The morals of one age are not necessarily the morals of all succeeding generations but their functions are the same in all societies. Modern scientific men don't eat their ancesters as moral imperatives but they must do what their reasons and consicences dictate. They must be rationally conscientious men, and there must be millions of them who are willing to measure what they do by what they *ought* to do.

Utilization of Natural Underground Water Storage Reservoirs

GEORGE D. CLYDE

The utilization of natural underground reservoirs as sources of water for increased municipal, industrial and agricultural needs offers great possibilities. Dr. Clyde discusses some of the methods that are being used to recharge reservoirs — especially in the west where the work has been under way for a number of years. Two conditions must be met to obtain full conservation and use of available water supplies. They are: To withdraw ground waters from underground resevoirs so as to create available capacity for storage, and to develop and practice artificial refilling of the underground reservoirs.

THE UNITED STATES as a whole is blessed with copious water supplies. They are not, however, well distributed either geographically or seasonally. In spite of the fact that the total precipitation which falls in the United States is ample to meet all water needs, critical shortages have developed in certain areas and seasonal shortages exist in many areas. To fully utilize the total water supplies, means of complete control must be developed. Before such control can be developed each stream basin must be characterized with respect to geology, vegetal cover, climate, precipitation and runoff. This means that basic meteorological and hydrological data must be collected before the time arrives for water control. Twenty-five to forty years of record are essential before hydraulic structures can be safely designed or uses of water developed.

Natural runoff does not usually coincide with the demand for use. Control by storage is necessary. The storage may be surface or underground. In both cases it can be developed by man and controlled by him The subject of this paper is the natural underground aquifier as a storage reservoir. Into it can be put surplus surface flow, sub-surface flow, salvage from municipal and industrial wastes, and by holding the water table down the water used by riparian vegetation can be greatly reduced.

Geologically, natural underground reservoirs consist of the openings, crevices, furrows, channels, in the bed rock of the earth's crust and the pore space in the sedimentary deposits and unconsolidated valley fills. These reservoirs are irregular in shape, intricate in form and of wide range in capacity. Their boundaries can be mapped and their hydrological characteristics determined. The waters in such reservoirs obey the laws of fluid mechanics. The reservoirs may be large or small in capacity and they may be full of water or practically empty.

The ultimate source of all water is precipitation which falls as rain or snow. A part of this water is evaporated directly into the atmosphere, a part runs off the surface into ponds, streams, lakes or the ocean, a part infiltrates into the soil mantle, is picked up by plant roots, used to develop plant tissues or transpired by the plant. Still another part, which is excess to the moisture-holding capacity of the earth mantle, sinks into the ground and ultimately finds its way into the underground storage reservoirs. When these reservoirs fill up and run over the water issues as springs. If the water in the reservoir is under hydrostatic pressure and a hole is drilled through the confining boundary, an artesian well develops. Otherwise, to get the water out of the underground reservoir it has to be lifted by pumps. As water is withdrawn from the underground reservoirs it is replenished in whole or in part by direct precipitation, natural seepage from river channels, ponds, canals and irrigated areas. In this respect an underground reservoir, although it cannot be seen, operates like a surface reservoir under the fill, empty, fill cycle, or, in other words, an underground water supply is not inexhaustible.

Development and Use of Ground Water

Ground water has been used by man since the beginning of time. The Bible tells of Joseph's Well in Egypt, a dug well through rock 18 x 24 feet in cross section and 165 feet deep below which it was 9 x 15 feet in cross section and 130 feet deep. A ramp was constructed around this hole from the surface to the bottom of the well. Drilled wells originated in China where they constructed both fresh and salt water wells. Their drilling tools consisted of a wooden rod with an iron cap on it tied to a rope. Their deepest well was 3,600 feet. For centuries there was no improvement in well drilling methods.

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Photo by Soil Conservation Service

Figure 1. This series of cross dams is built in the deep cut made by Cucamonga Creek where it emerges from the Canyon. The dams hold back and spread the water over the surface of the entire width of the creek bed, thereby exposing more percolation area.

Modern well drilling methods were introduced in France in 1841 when it took seven years to drill a well, 1,789 feet deep. About the same time a well was drilled near Paris to a depth of 1,923 feet and was 28 inches in diameter. A well at La Chapelle was drilled 1,000 feet deep with a diameter of 66 inches.

By 1850 French well drilling methods had been introduced into the United States and wells for culinary water were drilled at Charleston, S. C., Louisville, Kentucky, and St. Louis, Mo. The oil industry gave well drilling in the United States its greatest boost. Many wells were drilled for culinary purposes but it was not until the beginning of the twentieth century that ground water was used to any extent for irrigation purposes. By 1920 there was considerable irrigation pumping in California, parts of Utah, Colorado and Arizona. By 1940 extensive pumping for irrigation had spread to Utah, New Mexico, Texas, Colorado, and Arizona. The last ten years, however, have seen the intensive development in pumping not only for irrigation in the West but for supplemental irrigation in the East and for municipal and industrial purposes throughout the country.

Reports of the Geological Survey (1) indicate that in 1945, 13,900,000 acre-feet of ground water was used in 17 western states: 10,700,000 for irrigation, 1,200,000 for industries, 1,200,000 for municipalities, and 700,000 for rural uses outside of irrigation. For the entire United States the total was 22,900,000 acre-feet, nearly one-half or 11,750,000 of which was used for irrigation. In 1950 (2) California pumped a total of about 10,000,000 acre-feet of water from under ground. This is about 40 percent of the total ground water used in the United States. Arizona pumps over 2,000,000 acre-feet annually.

Some recent typical examples of ground water development and use:

1. Louisville, Kentucky, 1940—Industrial and synthetic rubber plants use 75 million gallons per day. The draft is double that in the Thirties. Safe annual recharge is only 40 million gallons per day. Water table dropping rapidly.
2. Winter Garden Area in Texas—Artesian wells originally discharged 30 feet above ground. Now the water level is 160 feet below ground surface.
3. In Texas three-fourths of the urban water supply comes from the underground reservoirs. In one day it is estimated that 4,000 acre-feet of ground water will be used to supply the needs of irrigation, industry and municipalities in Texas. It is believed by many that Texas is now living off its ground water reserve. It is estimated that the consumption of ground water in Texas has doubled in nine years, irrigation from wells increased four times, and cities have increased their pumpage from 10 to 100 percent in order to keep pace with increased population and industrial development.
4. In the south coastal area of California about 800,000 acre-feet annually are drawn from the ground water aquifers. This is nearly twice the total importations from the Colorado River, Owens Valley and Mono Basin to this area. There is an overdraft in this area and evidence of salt water intrusion.
5. In the Los Angeles area (2) there is an annual overdraft of 45,000 acre-feet. They are already drawing on the 2,000,000 acre-foot reserve in the 50-foot zone below the present water levels. Marine intrusion is developing.
6. In the central coastal areas from San Francisco to Santa Barbara a large part of the domestic, industrial and irrigation uses depend upon ground water. In many of the valleys the water levels have fallen below sea level. The gross annual pumpage in these valleys is 600,000 acre-feet of which 60 percent is in the Salinas Valley. The overdraft here is 30,000 acre-feet annually. Salt water intrusion is a problem here as well as in the Pajaro and Santa Clara valleys. All of the ground water sources around the San Francisco Bay area are in jeopardy because of salt water intrusion resulting from serious overdrafts.
7. In the Central Valley of California (2) ground water development has been rapid since 1910. By 1919 the total capacity of wells in the San Joaquin Valley was 7,300 and by 1929, 20,600 cubic feet per second. Overdrafts began occurring at that time. The estimated usable undeground storage capacity in this

area is in the order of 20,000,000 acre-feet. This huge reservoir capacity is what has made the long continued overdraft possible. In 1948 there were more than 35,000 pump wells in the San Joaquin Valley whose gross combined pumpage was in excess of 7,000,000 acre-feet. The maximum annual recharge is estimated to be not over 2 million acre-feet. Some means of increasing the annual recharge must be found or the huge reserve will soon be exhausted.

8. In Arizona over three million acre-feet of ground water are pumped annually. In three years, 1946-1948 inclusive, the water table over the Salt River Valley area dropped 19 feet. In some areas the water table has dropped 60 feet. It is quite evident that in Arizona they are drawing heavily on their ground reserve, which probably took generations to establish.
9. The High Plains of Texas is another critical area. In 1934 there were 300 wells irrigating 16,000 acres. In 1948 there were 10,000 wells irrigating a million acres. Here the overdraft is estimated to be about 20 to 1.

Development and Use of Natural Underground Storage Reservoirs

The development of ground water supplies for irrigation, domestic, municipal, industrial and other uses has caused a certain degree of involuntary utilization of underground storage. The amount of the annual recharge is a measure of that use. Such use will increase with greater draft on the ground waters and greater annual recharge either natural or artificial. If artificial recharge can be accomplished the ground storage can safely be drawn down to greater depths. In most areas where artificial recharging has been practiced, it has been limited to a stabilization of the water table in dry years and no deliberate attempt has been made to create additional underground capacity during dry years to be filled by water salvaged during wet years. With increased development of irrigation, municipal and industrial uses, however, the draft on the ground water will lower the water table and create additional storage capacity. The problem will then be to salvage and put underground sufficient water to fill this available capacity. There are still large quantities of water going to waste in most areas: Winter flow of streams, spring flood flow, sewage and industrial waters which may be salvaged. Carefully planned utilization of the immense potential storage capacity available in the underground aquifers, operated like surface reservoirs, will greatly increase the total available water supply. Frequently, a combination of small equalizing reservoirs can be developed in conjunction with the underground basins to increase streambed percolation and artificial recharge and thus achieve maximum conservation of water. To obtain full conservation and use of available water supplies and to stabilize the economy in areas dependent upon ground water supplies will require extensive utilization of underground storage to capture and make available for use surplus reclaimed waters. Two conditions must be met: (a) To withdraw ground waters from the underground reservoirs so as to create available capacity for storage, and (b) to develop and practice artificial refilling of the underground reservoirs. The overdraft in many areas has already created the storage capacity. The problem now is to learn how to refill the underground reservoirs with surface waters.

Photo by Soil Conservation Service

Figure 2. Head ditch feeding water to the several test strips of the Madera unit. Weirs and recording instruments made it possible to know exactly how much water flowed on and off of each strip, thus enabling accurate determination of percolation rates for each strip.

Refilling Underground Reservoirs

Artificial refilling of underground reservoirs has been practiced in Southern California since early 1900. (3) Present spreading in that area, exclusive of streambeds, indicates a development of 12,200 acres with an overall capacity of 5,100 cubic feet per second. These spreading areas cover primarily the alluvial fans at the mouths of the canyons. Three principal methods of spreading, with variations, have been used—furrows, basins, and wells or pits. Figure I shows spreading basins in a creek bed.

Furrow spreading seldom wets over 20 percent of the ground, but is generally low in development and maintenance costs and is therefore suitable where land is plentiful and cheap.

Basin spreading normally wets over 75 percent of the area used. It costs at present about $800 per acre to develop, including canals and control structures. An-

nual maintenance costs are about $80 per acre. Gravel pits are being used successfully to get water back into the ground.

Recharging through pump wells has been tried at intervals in many places and is currently receiving considerable attention. However, past experience has been rather unsuccessful except where clear water is available under high heads.

The costs of spreading vary widely. On one rocky detrital cone where ditches were used from 10 to 100 cubic feet per second of base flow have been spread over 500 acres for about 85 cents per acre-foot. On another area in the San Gabriel River Basin where intermittent large scale spreading of flood flow has been practiced, using a canal and basin system, the cost has varied from $3.25 to $5.25 per acre-foot annual operation and maintenance plus an average annual capital expense of $2.00 per acre-foot. Experience in Los Angeles County (4) indicates rates of infiltration may vary from 1.5 to 10.0 acre-feet per acre per day. This is cheap storage, because frequently in Southern California water in ground water basins has a value of $35 to $40 per acre-foot.

Spreading water over alluvial fans to recharge underground aquifers is a proven practice as is evidenced by the experience in Southern California: San Antonio Creek, average percolation rate 5.00 acre-feet per wetted acre per day; San Gabriel River Area, two to three acre-feet per wetted acre per day; Tujunga Wash, three to ten acre-feet per wetted acre per day. Similar but more limited experience in Utah and Arizona have demonstrated the effectiveness of spreading on alluvial fans. In Southern California over the past nine years, the total artificial recharge to the ground water basins has been over 655,000 acre-feet.

The several methods of spreading that have been developed (5) have proven effective. Each has its advantages and disadvantages. These methods may be used separately or in combination, depending on the topography, land available, vegetal cover, condition of the water (silty or clear) and the streamflow characteristics. These methods are fully described in U.S.D.A. Technical Bulletin No. 578. To maintain continuing high rates of infiltration, spreading works must be continuously maintained. Silty water tends to seal up the surface. Therefore, where possible it should be desilted before spreading or the surface of the spreading grounds will have to be broken up at intervals. The presence of native vegetation tends to greatly increase the infiltration rates. In Utah spreading in patches of native oak brush has proven very effective.

Recharging through wells or shafts has been tried with little success. To use pump wells for recharging during the non-pumping season has been found in many cases to be detrimental to the well. This is due to silting up of the aquifer around the well casing. Even relatively clear water will in time seal up the porous material next to the well screen. A well, if it were to take only two acre-feet per day of water containing one ounce of silt per 1,000 gallons, would take into the aquifer surrounding the casing 1,200 pounds of silt per month.

Recharging through well casings accelerates the incrustation of the well screens. Biological activity may form jelly-like substances which seal off the pores.

In spite of these difficulties there is a growing practice of this type of recharge, particularly in cities where cooling water is returned to the underground aquifer and where spreading areas are not available. Greater use of wells, pits and galleries can be expected as methods are developed to maintain the infiltration rates.

Current Research

Methods of recharging ground water aquifers by spreading water over alluvial fans or other porous areas using natural stream channels, ditches, basins, furrows or flooding, have been developed, proven successful and reduced to practice. They are adequate to use up limited water supplies wherever satisfactory spreading areas are available. However, to recharge large underground reservoirs such as those in the Central Valley of California, Salt River Valley of Arizona, or the High Plains of Texas where large quantities of water must be put underground annually, at rapid rates, through fine valley sediments, new methods must be developed. For example, in the San Joaquin Valley of California as a part of the Central Valley Project, it is planned to divert Class 2 water at the Friant Dam, convey it through 165 miles of canal and put it underground to recharge the huge underground storage reservior in the vicinity of Bakersfield. The amount of water to be stored varies from 800,000 to 1,500,000 acre-feet annually. The spreading period is short and the value of the land high. Therefore, it is imperative that the infiltration rates be kept high.

Where spreading ponds have been kept submerged for long periods, it has been found that the infiltration rate decreases after the initial wetting until in some cases it approaches zero. This sealing may be due to a change in soil structure or caused by bacterial activity in the soil or the result of chemical changes in the soil.

In 1944 a cooperative project was started by the Soil Conservation Service, the North Kern Water Storage District, and the State of California, near Bakersfield, California, to determine the causes of the decreased infiltration rates and to develop methods and management practices that would maintain high infiltration rates. Two sets of test ponds were built on different

Figure 4. Spreading cotton gin trash on Minter Field test areas. Photo by Soil Conservation Service

soils using different spreading water. These test ponds were set up to study the effects of chemical treatments (addition of gypsum, copper sulfate, calcium chloride, etc.), mechanical treatments (spading, discing, removing topsoil, etc.,) management practices (depth of water in ponds, drying periods, desilting water, etc.), addition of organic matter (alphafa hay, cotton gin trash, fertilizers, grass mulches, etc.), and vegetative trials (growing various grasses or crops). Figure 2 shows water spreading test strips at Madera, California.

Four years of test pond work indicated that the best treatment was the use of cotton gin trash which was wet for about 30 days after which it was allowed to dry. The infiltration rate after the drying period started out high and remained high. After five years the ponds treated with cotton gin trash still show a high infiltration rate. Field trials are now being run on six acre plots to see if test pond results can be duplicated in the field. Figure 3 shows the Minter Field spreading areas. Figure 4 shows method of spreading cotton gin trash on water spreading areas. The next best treatment was the use of Bermuda grass as a crop.

In 1947 a laboratory was established at Bakersfield to study the soils and biological aspects of this problem to determine the reason for the results of the cotton gin trash treatment and to find a synthetic amendment which would act like the cotton gin trash. Other organic materials such as alfalfa, redwood sawdust, and potato vines are being studied. Some substance in the cotton gin trash seems to cause an aggregation of the soil which increases infiltration rates.

More information is needed on the amount of gin trash to use, the length of the incubation period, the degree of wetting during incubation, the length of the drying period, the degree of drying, and the duration of the beneficial effect. Would a leachate from the trash be as effective? What part of the gin trash is doing the work (leaves, bolls, hulls, etc.)? Can the effective substance be synthetized? Will the effect be the same on large spreading ponds?

The final answers are not yet available. Continued research, however, will develop techniques and establish practices which will permit successful recharging of ground water aquifers. The practices can be applied wherever surplus or salvage waters are available and underground aquifers within reach. Artificial recharging of underground aquifers will permit salvage of surface waters and increase and stabilize underground water supplies. The practice should be established in all areas where there is an overdraft on present ground water supplies and especially where there is danger of salt water intrusion.

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Wood Chips, Water and Soil

ARTHUR C. McINTYRE

There is a growing interest in the use of chipped wood for mulching by orchardists and vegetable growers; also for bedding and litter for livestock and poultry. To make these uses possible, a wood chipper has been developed to utilize brush and orchard clippings. Mr. McIntyre clearly shows the economic and physical values of this pratice as it relates to soil improvement and moisture conservation.

OF ALL THE THINGS MAN can do to curb soil erosion or impound rain none is more effective than those that maintain optimum amounts of organic matter in or on the soil.

When we talk about a soil or water conservation practice, we seldom use the words organic matter or humus. We talk about crop rotations, cover crops, green manure crops, mulches, tree and shrub plantings, woodland and pasture management, and in so doing indirectly recognize that organic matter, living or dead, is responsible for predetermined desirable effects.

The protective effectiveness of organic matter in soil depends in part upon the amount, time and percentage of lignin. Wood is high in lignin. A fragment of wood, of course, is quite different from a blade of grass and their conservation values, as organic matter, can be quite different.

There are at least six uses for fragmented wood on a farm, all of which are related to soil and water conservation. These uses are:

(1) as a soil conditioner or amendment;
(2) as a mulch for crops;
(3) for animal bedding;
(4) as a poultry house litter;
(5) as a soil covering on yards, grounds or roads; and
(7) for composting.

Editor's Note: Because of space limitations the discussions and references relating to items five and six above have been deleted from the original paper; the text in certain other parts of the paper has been shortened.

There are other uses too. Shavings, sawdust, excelsior and small chips are used by nurserymen as packaging material and as a propagating medium for some shrubs and flowers.

Wood chips can be used as fuel and may be found more economical than chuck wood. Farmers harvest thousands of cords of pulpwood from their woodland. This bolt wood is reduced to chips at the mill before conversion to paper. Semi-portable wood chippers have been tested and are now being used to reduce chunk wood to chips, thus eliminating much labor otherwise required. The use of chippers in this way is comparable to the use of the combine as contrasted to the binder in harvesting grain.

Those, then, are of fragmented wood in soil and water conservation. In a moment we shall discuss each of them. But first, let us look at the picture as a whole.

Wood, as trees and shrubs, is present over large portions of the earth's surface. Wherever virgin forests occurred, the mineral soil mass they blanketed became enriched and this enrichment was impounded to be released for use when man cleared the land and subjected it to his needs for plowland and grassland.

Time, physical changes and chemical reactions, interwoven with the remains of forest flora and fauna, produced a rich heritage for man's use. Newly cleared land gave bountifully at harvest time. As the stored wealth of humus and soil structure was drawn upon by harvest and by thieving, cascading surface waters, productivity declined. This loss of once fertile fields did not at first cause alarm; there was more good forested land to be cleared. Soil loss and gullies were thought of as natural phenomena to be lived with.

This type of thinking has resulted in the impoverishment or destruction of thousands of acres of farm land. As soils have lost their humus and blanketing organic matter, erosion has accelerated. Floods have become more damaging.

Knowledge accumulates on what to do to correct mistakes and prevent their recurrence. There are well defined techniques that will permit the sustained use of land without undue concern for soil or water loss. Fragmented wood can be used in carrying out some of these soil and water conservation practices. Wood to meet these uses is available in woodlots and adjacent forested areas. Possibly in the years ahead, wood, grown in the

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woodlot, will be reduced to chips and used directly or indirectly as a routine conservation measure.

Wood for Organic Matter

Common to all types of farms is management of land —soil—and the production and use of organic matter. Soil management concerns itself with maintaining productiveness, which is basically dependent upon humic content.

Crop rotations, green manures, use of crop residues and animal manures are used to maintain farmed land in workable and productive condition. To organic matter, lime and fertilizers are added.

The immediate effect of incorporating wood fragments in soil is to improve structure and water-holding capacity. (24) Heavy soils are particularly responsive. Studies on a silt loam, low in humus, showed that sawdust plowed in at the rate of eight tons per acre improved water-holding capacity by 15 percent and that water stability of aggregates improved 50 percent in two years. In an irrigated orchard on a heavy soil, the use of two inches of sawdust plus a green manure crop resulted in improving soil structure so that, in two years, one irrigation was saved.

Wood, like any organic matter, is attacked by fungi and bacteria, decomposing to form a humic substance depending in amount and kind upon mineral and lignin content. Woody materials also contain appreciable quantities of carbohydrates which furnish energy for the growth and activity of micro-organisms. The nitrogen content of woody materials is comparatively low. The micro-organisms that attack woody (or any organic) materials require nitrogen to make proteins for their bodies. Most of them cannot use atmospheric nitrogen and so must get is elsewhere. Consequently, when organic substances decompose in soil, a temporary shortage of available nitrogen is likely to occur unless it is made up. (7) (25) Under certain conditions, there may be a temporary phosphate deficiency. The N-P-K value of wood is about 4-2-4.

Wood does not make soils sour or acid. (14) (25) When excessive amounts of some wood or bark are used a temporary acidic condition may develop but is of short duration. It has been found that the continued use of wood will raise pH values. (8) (23) The widespread idea that incorporating raw wood into soil will make it acid is the most important single factor accountable for farmer reluctance to use wood fragments.

Organically, wood varies with species and age. It is composed of about 60 percent cellulose, 28 percent lignin, 1 percent mineral, and the balance, 11 percent, waxes, resins and terpenes. Due to its high lignin content, wood can build up humus faster than herbaceous plants used as green manure or cover crops which are nearly all cellulose. Lignin alone materially improves soil structure and has been recommended for use as a soil conditioner. Lignin is highly resistant to the decay action of organisms. (1)

Humus acts as a buffer to nitrogen demands. Soils high in humic content (three percent plus) can more readily absorb free organic matter without reflecting depressive effects on crops than can soils low in humus. This further supports the desirability of maintaining optimum humic levels. The amount of nitrogen necessary to meet needs of organisms depends largely upon the amount of cellulose and size of organic material. High cellulose organic matter breaks down more rapidly than wood, which is rich in lignin. Decomposition is largely a surface phenomenon. Hence, the greater the surface area, as with sawdust fragments, the more rapidly organisms can work. And their demand on nitrogen is much greater.

It will not be necessary to use as much nitrogen when discing in coarse wood chips as when discing in an equal volume of sawdust. Studies on the use of sawdust as a soil amendment indicate that about 50 pounds of $(NH_4)_2SO_4$ should be used per ton. One percent nitrogen has been proposed as a rule-of-thumb for sawdust. (24)

In using wood chips as a soil conditioner their size can be governed and thus, in a measure, influence nitrogen applications. There is need for studies on the influence of size of wood fragments, soil type, and nitrogen requirements.

Because conventional farming methods cannot maintain desirable levels of humus and because growing plant materials only for this purpose is costly in terms of land use, labor and materials, an alternative would be to draw upon surplus wood produced in the woodlot. In terms of the conservation objectives of using land in accordance with its capability and needs of the farm, such a practice has much to recommend it. Woodland products can improve and maintain values of plow and grassland and contribute to soil conservation.

Wood for Mulching

Let's take a look at fragmented wood for mulching. There are three reasons why mulching is a good soil and water conservation practice: (1) it keeps the surface of the soil loose and friable, thus increasing penetrability and retarding run-off; (2) it absorbs the energy of raindrop impact, thus reducing erosion; (3) it reduces soil temperatures and thus conserves moisture by preventing or hindering evaporation. As a factor in maintaining soil porosity, mulch insulates the soil against early or quick freezes thus protecting worm populations.

Mulching contributes to crop production and management by: Reducing or eliminating weeds and grasses that compete with crops for nutrients and water, protecting plants from winter injury, protecting fruit from spattered dirt or cushioning its fall, and keeping soil from being compacted or puddled when time demands of season, labor, and machinery necessitate operations when the soil is too wet to work.

The residue of mulches becomes incorporated in the soil and aids in building up or maintaining humic content.

Straw has been the most generally used mulch material. Hay, weeds, seaweed, sphagnum, peat moss, shavings and sawdust are also used. Experiment stations have reported that, when properly used, a mulch of any material has always been found beneficial as a conservation practice. (20)

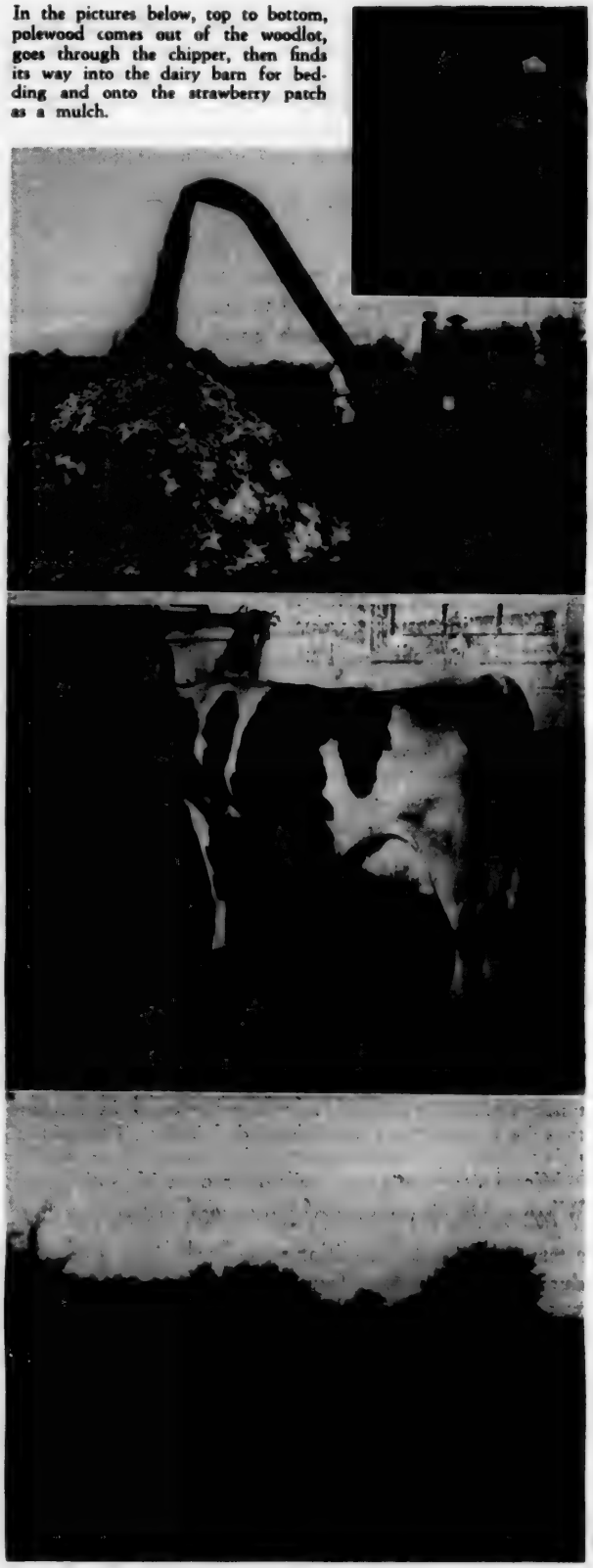
Due to the multiple values of mulching more farmers would adopt this practice if low cost mulch materials were available. An extension specialist reported that if a mulch material could be purchased for $8 or less a ton 75% of the apple orchards would be mulched.

Studies have shown sawdust and shavings effective in the garden, berry patch, orchard, and nursery. (26) (24) (23) (12) (9) There are farmers who, after many years of using sawdust and shavings as a mulch and soil conditioner, know that wood fragments can serve agriculture. They learned by doing. (8) Some have pioneered. Their experience and "know-how" should be collated and publicized.

When an organic mulch is used, enough nitrogen to offset decomposition requirements should be supplied. If not, plants will be affected because they are deprived of nitrogen by demands of decomposing organisms. Six to seven pounds of a nitrogenous fertilizer (ammonium sulphate) per mature apple tree per year are enough when a ten-inch sawdust mulch is used. A rule-of-thumb is one-quarter pound of $(NH_4)_2SO_4$ for each year of tree age when starting a new orchard and maintaining a four to six inch sawdust mulch. For blueberries an ounce of 7-7-7 applied twice each year, for each year of age, until a total of eight ounces is being used, has been found adequate. For strawberries, 50 pounds of an 18 to 29 percent nitrogen fertilizer per cord of sawdust is reported acceptable. A six inch sawdust mulch will remain effective and require no maintenance for from three to five years. Straw and hay mulches usually require annual care.

The cost of mulching will vary with the prices paid for material, labor and haulage. In many communities throughout the forested regions sawdust is given away or sold at low cost. Its cost as a mulch, when starting a

In the pictures below, top to bottom, polewood comes out of the woodlot, goes through the chipper, then finds its way into the dairy barn for bedding and onto the strawberry patch as a mulch.



new orchard, has been computed at 45 cents per tree when using 18 cubic feet. Maintenance requires application of the same amount every three years. Cost per tree over ten years would be $1.80 or 18 cents per tree year. Wood chips can be made for less than $5 per ton. If they are used, cost per tree would be 70 cents for chips, plus 45 cents for application, or $1.15 per stem, Cost for ten years of mulching would be $4.60 or 46 cents per tree year.

Straw and hay are the commonly used mulch materials. It is seldom that they can be purchased for less than $10 a ton. Recommendations for mulching a bearing tree is 300 pounds with an annual maintenance of 100 pounds. Cost of material for a ten year period would be $6 to which must be added application costs of labor and machinery, which would approximate $1.50. Three year cost would be 75 cents.

It requires about 27 cords of sawdust or chips to provide one inch mulch over one acre. A cord of coarse chips, produced from live trees, will weigh about one ton.

It is routine practice for orchardists to dispose of prunings by burning or dumping. Chippers and hogs coming into use provide for direct field disposal and thus leave the wood fragments as a mulch under or between trees. Chippers are now designed for mounting on farm tractors and utilizing power take-offs. Using these chippers, pruning costs have been halved. It is possible to move through an orchard with a tractor-mounted chipper and by feeding polewood through it, have the chips blown directly under trees to form a mulch.

Wood for Bedding and Litter

Bedding materials can be evaluated in three ways: (1) costs, in terms of production or purchase, and their handling in and out of the barn; (2) effectiveness as a bedding substance; and (3) agronomic value.

The costs of bedding materials are extremely variable depending upon kind and availability.

With the swing to grassland farming and acre reduction of certain grain crops, less straw or shredded corn stalks are locally available for bedding. (6) In some sections of New England dairymen find that even sawdust and shavings are not produced in volume to meet needs. Wood chips are being used to provide an acceptable low cost bedding.

Cost of using various bedding materials, their storage, and the handling of resultant manures, are important items.

Wood fragments can be stored in bins and readily drawn off into conveyors, thus reducing handling costs. They give better service than does straw when gutter cleaners are used. Sawdust, shavings, or wood chip manures are easily handled by spreaders and field distribution is more uniform than with strawy manures.

The most valuable characteristic of a bedding material is its capacity to absorb liquid manure. (16) (19) Studies have shrown that sawdust and shavings will hold as much as hay, straw, or shredded cornstalks. In tests, sawdust has been rated first in handling quality and tendency to break up. Wood chips, because of their varied size and shape, will "stay put" better than sawdust, give a neater appearance to the stall and animals, produce little dust, and will not be readily floated away by liquid manure.

Coarse wood fragments are excellent for use in the loafing barn. They provide a resilient and absorptive bedding. Fresh amounts can be progressively added and at season's end the mass of accumulated manure readily removed. Such coarse woody manures provide excellent mulch material.

Ten pounds of bedding per animal day is a general recommendation. This rate will produce a final manure containing from 12% to 15% of bedding by weight.

A ton of manure contains about 1,300 pounds of organic matter. N-P-K values will vary with the type of bedding. A wood fragment manure will contain about 13 pounds of N, six pounds of phosphoric acid and 12 pounds of potash.

The value of manure as a soil conditioner and conveyor of plant food is well established. (18) It is also recognized that available volumes of manure are insufficient to meet the needs of good soil husbandry. The tonnage of manure can be increased by using more bedding which, on many farms, would also improve barn management.

As the bedding content of final manure increases, the amount of N-P-K per ton would decrease, but any disproportion can be offset by adding these and other elements. When ten pounds of wood fragment bedding are used per animal day about 40 pounds of ammonium nitrate or its equivalent should be added per ton of manure so as to establish an acceptable carbon-nitrogen ratio. It is thought that as much as 20 tons of woody manure properly treated can safely be incorporated in the soil at one time. (2) At a federal nursery as much as ten tons of fresh sawdust and chips per acre are used annually.

Heavy manuring is an excellent soil and water conservation practice. By increasing amounts of bedding an increased tonnage of manure becomes available. Wood fragments can meet the volume low cost requisites to secure farmer adoption of this practice.

Wood chip manures should give as good mulch effects as strawy manures.

Wood chip manures fit very well into a grassland farming program. In contrast to strawy manures, they quickly sift down through the grass, where needed, and do not mat or have a tendency to blanket vegetation.

Wood shavings provide an excellent poultry litter. For broiler house use, coarse chips have been found satisfactory, and air-dried sawdust and fine shavings are among the best of litters. (22)

The type of litter desired varies with the species, age, poultry product produced and operators' experience. Wood chips, sized to meet requirements, can become a preferred type of litter material. They should rank first when judged in terms of the characteristics of good poultry litter. They will not pack and, because each chip has a tendency to shift or flip over when stepped upon, droppings sift through to the floor, thus maintaining a desirable cleanliness.

A Conservative Tool

Accepting the fact that fragmented wood can serve farming in many ways, it still must be readily available and at low cost. Mills are not producing enough sawdust or shavings.

Wood fragments could be produced at central points where chippers, hogs, shredders or hammer mills are operated, but handling of chunk wood and transportation costs tend to put a price premium on products. (17) (5) From the over-all standpoint, it is desirable to have a portable machine which can move to the farm and about the woodlot where wood is piled, thus affording farmers opportunity to advantageously harvest their own fibre crop.

Portable chippers are available and their successful use by a few farmers demonstrates that these machines can contribute to farming. Attention has focused only lately on these chippers as a conservation and farm tool. Early designs are being improved that are increasing efficiency and flexibility of use.

Operational studies show that wood chips acceptable for use as bedding, litter or mulch can be produced on the farm at low cost. (4) More than a cord of pulpwood can be run through these chippers in an hour. (11)

Summarizing management and cost items: (Averages and rules-of-thumb).

A cord of green polewood weighs about two tons.

One man can cut and place in piles two cords of trees or long-length polewood in a day.

Chipping a cord of poles will produce about 240 cubic feet of chips. A cord of chips weighs about one ton.

Estimated cost per ton of chips loaded on farm truck —$5.00, which is computed on the basis of paying $5.00 per hour for custom chipping, plus labor cost for cutting the polewood. There are few localities where straw or hay can be purchased for less than twice or three times the cost of chips.

Wood Chips and Woodland Management

Nearly every farm throughout the forested regions has a woodlot. As a sound basis for soil and water conservation programs, land should be used according to its capabilities. The most valuable use for some farmland is to produce wood products and have on it a protective cover of woody vegetation. There is need for a sustained maximum yield of quality woodland products from these areas. From the woodlots farmers should get enough wood for themselves and manage them for labor income. Every woodlot produces some wood that, because of its physical condition, is not merchantable. There are also those species having little or no market value. In many woodlots trees crowd each other and some should be removed to provide growing space. Any improvement or harvesting operation produces slash in the form of tops, limbs and other unused portions of the tree. From these classes of usually waste material, wood can be obtained for chipping and farm use.

The basic reason farmers are not responsive to the woodland management recommendation of farm forestry is the low dollar return for labor input. Farmers do harvest some wood from their woodlots for home use, but less than 5% of the farm woodland acreage is receiving adequate management. If wood chips can adequately serve where other materials are now used or where scarcities and high prices exist, the labor input return requirement can be satisfied. Then conservation programs will profit in two ways: (1) increased amounts of organic matter will become available to blanket the soil and build humus and (2) the farm woodlots, representing one-third of our commercial forested acreage, can profitably receive improvement treatments that they urgently need. (15)

General acceptance of the routine use of wood chips on farms would be the greatest single factor to creating demand for farm forestry assistance and initiation of woodland management practices.

Looking Ahead

Organic matter is intimately associated with soil and water conservation. Providing for its use and presence is a conservation measure. Its presence or absence on the land, living or dead, and in the soil, is a most critical factor when evaluating the influence of other conservation practices.

As pressure on the land increases, forcing it to pro-

duce more food and fibre to serve an expanding population, it is unlikely that the years of grass will be lengthened in crop rotations, or that there will be crop organic matter surpluses to plow down so as to build up or maintain humus levels. Nor can grassland farming meet the cereal and economic needs of millions of people.

Woodlots and forests are great reservoirs of organic matter that can be drawn upon to meet the needs of soil husbandry, and conservation farming.

In harvesting this organic matter, woodland can, at the same time, be so managed as to produce more abundantly.

The requirements for acceptance of making full use of wood from the conservation, agronomic and farm management viewpoints, is dissemination of knowledge on "how" and by providing efficient machines that can convert trees into wood fragments that are physically adapted to meet requirements.

That wood fragments can serve farming has been satisfactorily demonstrated by a few farmers who have used sawdust and shavings for many years. Research has established facts in proof of successful farmer experience. Knowledge is not complete. Very few comprehensive studies on the several farm uses of wood fragments have been undertaken. If one-tenth as much attention had been given to the agronomic use of wood as has been given to any other crops, there would be fewer farmers and professional men believing that wood makes soil sour and should not be used as an organic amendment.

Some years ago, a slogan contest resulted in the adoption of *"Certified By Centuries"* as a distinctive statement referring to permanence of homes built of wood. This slogan takes on added significance when thinking about the possibilities of using wood to maintain humus, so that our farmland can continue to be productive.

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A Professional Man's Responsibility

FRED A. WIRT

"I hold every man a debtor to his profession; from the which as men of course do seek to receive countenance and profit, so ought they of duty to endeavour themselves by way of amends to be a help and ornament thereunto."
—Francis Bacon, 1561-1626

THUS DID SIR FRANCIS BACON—in a single, pungent sentence—express the basic "why" of membership in a professional organization. Thus, too, did he provide all professional conservationists with the one critical consideration which makes imperative their active membership in the Soil Conservation Society of America.

There is no better way of course for a professional man to serve his personal, family, business and community interests than by doing his chosen work as best he knows how. That is his privilege and his obligation, but its achievement calls for constantly seeking out helpful information from others in the same field. He grows in knowledge and prestige through such association. By friendly exchange of ideas and experience, by cooperating with colleagues in a constant sifting and winnowing of thought and subject matter, he reaps a double benefit. For he not only increases in personal stature; he also contributes to the general advancement of his professional group.

There is still another advantage to active membership in a professional organization which cannot be too strongly emphasized. I refer to the *inspiration* which arises from contact with others engaged in similar work. Very few of us are "natural" self-starters who can carry on without periodic stimulation and encouragement. Most of us need the occasional "hypo" which we can get only from others who are strongly interested in achieving objectives similar to our own.

Members of the Soil Conservation Society of America can obtain both information and inspiration by attending national, sectional and local meetings of the society and its chapters. Contact with members from other sections of the country has always been one of the major advantages of membership in a technical organization. And participation in commitee acivities serves to step up this advantage. For the conservationist who is ambitious to go forward personally—and at the same time make a real and lasting contribution to conservation—committee activity offers an unequaled opportunity.

The Soil Conservation Society of America renders still another basic service through the publication of its Quarterly JOURNAL. The JOURNAL's informative technical articles, story-telling illustrations and high-level, *professional* advertising are "must" reading for anyone interested in the conservation of renewable natural resources. The society regularly issues NOTES AND ACTIVITIES to keep its membership informed of current society affairs, and occasional special reprints are also sent to members.

Theodore Roosevelt—three centuries after Sir Francis Bacon—said it quite differently but with equal pungence:

"Every man owes a part of his time to the up-building of the profession to which he belongs."

For the professional conservationist—whether he is employed in private industry or in government—whether his work is directly or indirectly connected with conservation of soil, water or the living resources—there is one practical and potent means of resolving that professional obligation.

That means is through active membership in the Soil Conservation Society of America.

Fred A. Wirt is Advertising Manager for the J. I. Case Company with headquarters in Racine, Wisconsin. He is also a member of the Soil Conservation Society of America Council and Chairman of the Society's Membership Committee.

Unity on Professional Standards Objective of Society

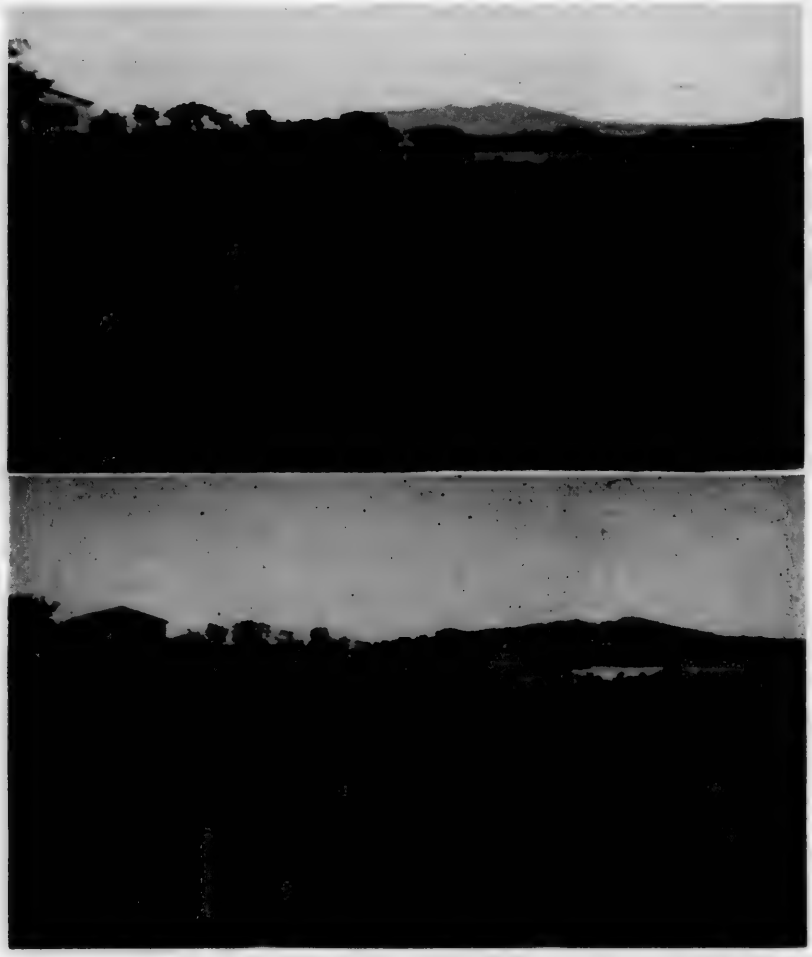
Facts established through research or otherwise, are of little value unless understood by the land operator. The methods of informing him must be such as to inspire and arouse in him a desire to act. Neither facts nor information are of much value unless they result in application on the land.

Soil conservationists in seeking the greatest possible degree of unity and agreement among themselves on professional standards would naturally turn to . . . an organization having as its primary objective the promotion, advancement, and application of the science of soil and water conservation.

—R. H. MUSSER, *From President's Annual Address Published in the July 1946 number of this* JOURNAL.

The carrying capacity of this improved pasture on class IV and VI land in Wake County, North Carolina, is better than one animal unit per acre during nine to ten months each year. The land originally had been row-cropped and was badly gullied. Fully 75 percent of the topsoil was gone. The predominating plants in the pasture are Dallisgrass and white clover with n tive Bermuda-grass gradually increasing. All this is based on proper land use, good pasture management along with liberal applications of lime, phosphate and potash.

Conservation Practices in El Salvador, Central America



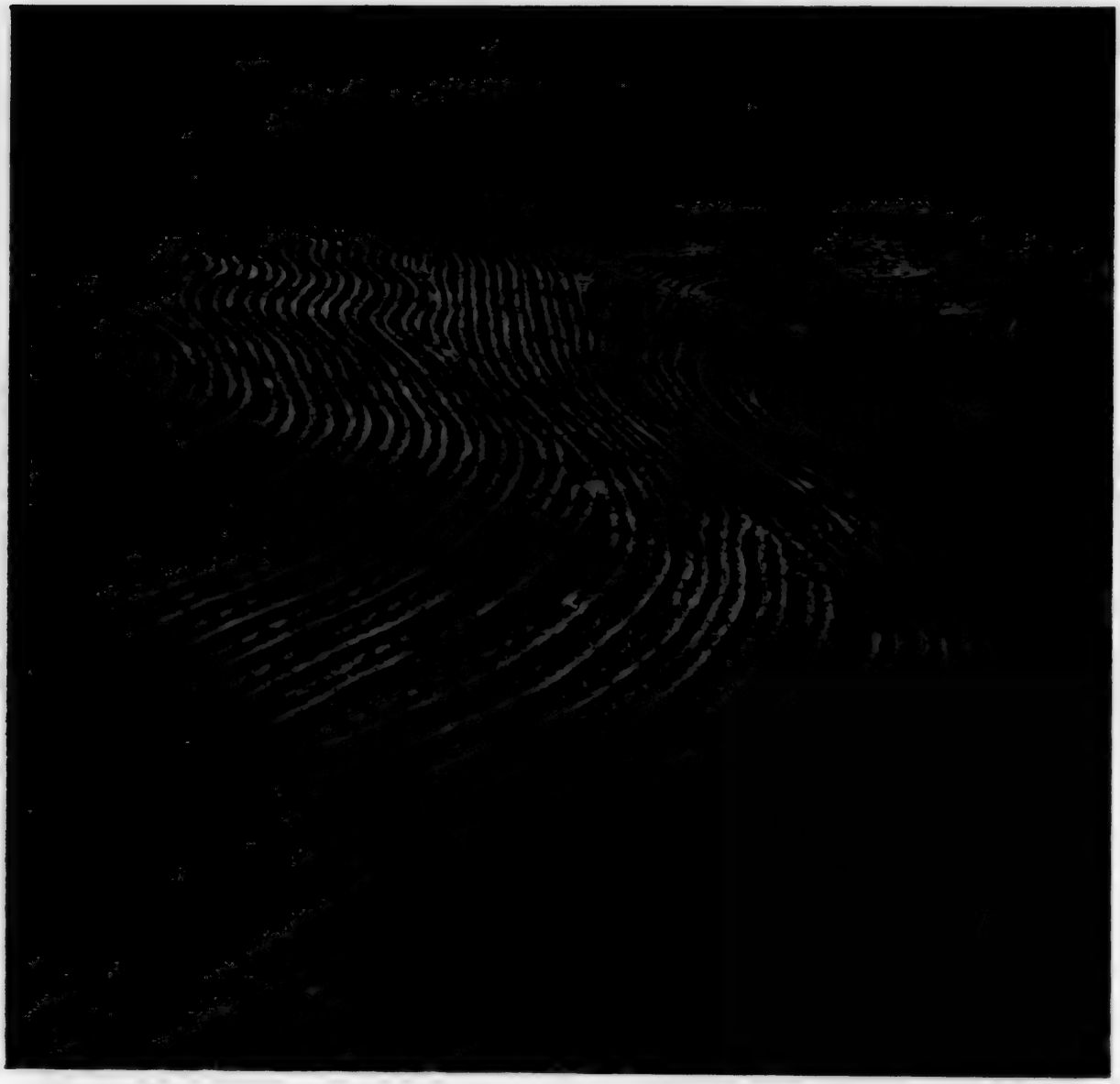
The photographs on this page were provided by Manuel J. Chavez Viaud. Mr. Chavez, a leading Agronomist, is associated with the Centro Nacional De Agronomia, El Salvador, Central America. He is also an active member of the Soil Conservation Society of America and a frequent contributor to the *Journal*.

The two photographs on the left show grass barriers estabilshed on the contour to protect crops. Grasses used for this purpose are: Guineagrass (*Panicum maximum*), Lemongrass (*Cymbopogon cetratus*), *Violetagrass* (*Anatherum zizanioides*), and Elephantgrass (*Pennisetum purpureum*).

The photograph on the right shows a series of izote barriers (*Yucca elephantipes*) established on the contour to protect new coffee plantations. Land in this area is steep and requires conservation measures to conserve water and keep the soil from eroding.

This aerial view of a farm community in Minnesota presents an excellent study in the use of contour strips on eight adjoining farms. Proper land use, grass waterways and many other conservation measures have contributed much to make agriculture in this community a vital factor.

Farmers in Stone Valley near Sunbury, Pennsylvania, have done much to change the landscape of their farms. The contour strips and other conservation measures shown in this aerial view brought about an increase in crop yields of ten to 25 percent, greatly retarded flood waters, improved the quality of livestock and made the valley a better place in which to live.



The contoured citrus grove shown in this photograph is located near Clermont in Lake County, Florida. The trees are spaced 25 feet apart around the slope and 30 feet apart down the slope. This type of layout, because of the deep sands in which the trees are planted, makes for greater ease in the operation of equipment as well as better retention of fertilizer and moisture. Lake County Soil Conservation District has more than 1500 acres of citrus trees planted on the contour. The largest of these groves is located near Montverde covering over 400 acres and claimed to be the largest in the world.

Structure and Sandy Soils

R. L. COOK

Fertilizer placement studies conducted on Hillsdale sandy loam soils in Michigan showed that corn roots were slow to reach plowed under fertilizer because of the compaction of the soil after the land was plowed. The compaction was caused by rain and tillage. In a comparison of cropped and fence-row sandy loam soil it was found that the fence-row soil, high in organic matter, did not pack and did allow rapid percolation of water. The cropped soil was found to be very compact at the surface and at plow depth. It did not allow rapid water percolation.

SANDY SOILS are not always loose and well aerated. Under certain conditions they may become so compact that plant root penetration is extremely slow. As a result the plant may be unable to obtain sufficient nutrients. This has been indicated by slow growth, the occurrence of nutrient deficiency symptoms, and finally by low yields.

Much has been written about keeping sandy soils firmly packed to avoid excessive organic matter losses through soil organism activity. It has been suggested that such soils should be plowed only when it was absolutely necessary to turn under trash and vegetation. Evidence now exists that such advice needs to be carefully given, with due consideration to the particular nature of the sandy soil in question.

At the Michigan Station it has been shown that where Hillsdale sandy loam was tilled only with sweeps, corn starved for potassium much more than it did where the land was plowed with a moldboard plow.

For many years this station conducted field experiments on Fox sandy loam in Cass county, Michigan. Quite frequently during those years, poor stands of alfalfa resulted because the soil crusted so badly that the plants were unable to emerge. This condition came about as a result of heavy rains after planting and before emergence.

It is the purpose of this paper to present evidence that excessive packing of sandy soils may be as undesirable as the packing of heavy soils. Excessive packing of sands is difficult to avoid because of the characteristics which they do *not* possess, namely, that of *granulation*. Evidence seems to point to the fact that this applies particularly to those which contain enough clay to class as sandy loam and to those sands which contain a high percentage of fine and very fine sand.

R. L. Cook is Professor of Soil Science, Department of Soil Science, Michigan Agricultural Experiment Station. Mr. Cook presented this paper at the annual meeting of the Soil Conservation Society of America held in Detroit, October 26-28, 1950.

Experimental Results Far Reaching

Corn fertilizer placement experiments have been conducted by this station on a variety of soil types. Included among the various treatments were those which provided for row applications at various depths at planting time, and applications on the furrow at plowing time.

On Hillsdale sandy loam on the college farm, potassium has usually been the first limiting factor in growth, so far as nutrients are concerned. Green tissue tests (1) have made it possible to tell when the corn plant roots reached the potassium applied in the fertilizer. The results obtained from one series of tests are reported in Table 1. Throughout the month of July the corn on the unfertilized plots was so low in potassium that the test was blank, an indication of starvation for that element. Similarly where the fertilizer was plowed under, the test results were blank or low. The plants were getting very little potassium from that applied in the fertilizer. The height of the plants furnished similar evidence.

During the same period the corn which had grown where fertilizer was applied in the row or two inches below the row was either medium or high in potassium and was much taller. On those plots the plants were getting potassium from the fertilizer.

Where the fertilizer had been placed six inches below

Table 1. Effect of Fertilizer Location on the Potassium Content of Corn Plants on Hillsdale Sandy Loam

Treatment	Potassium in green tissue and plant height					
	July 1948					
	1	6	10	15	20	24
No fertilizer	B	B — 6″	B	B — 14″	B	B
Plowed under	L	B — 6″	B	L — 14″	B	L
In row	H	H — 14″	M	H — 22″	H	M
6″ under row	L	M — 11″	H	H — 18″	H	M
2″ under row	H	H — 13″	H	H — 22″	H	H

Symbols—B, L, M, and H mean blank, low, medium, and high.

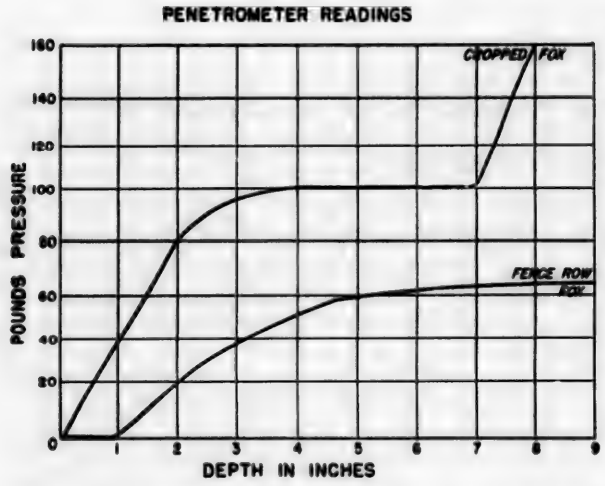


Figure 1. Compaction of Fox sandy loam in a cropped field as compared to a blue grass covered fence row. The clay and silt contents of the two soils were identical.

the seed, at the same depth as that which was plowed under, the tests indicated only a short delay in the time when the roots reached the potassium. Thus the failure of the corn to reach the plowed under fertilizer was not due to fertilizer depth but rather to the fact that the soil had become so compact it could not be readily penetrated by the roots. This compaction had occurred during the several weeks which had elapsed since the land had been plowed. Some considerable amount of rain had fallen and the land had been harrowed several times to eradicate weeds. On the plots where the fertilizer had been placed deep at planting time, the compacted soil was loosened by the opener which deposited the fertilizer. Through that narrow opening the roots were able to penetrate to the potassium.

A Comparison of Cropped and Fence-row Soil

In connection with a dairy cattle nutrition study, the Michigan Experiment Station has a farm located on Fox sandy loam where some of the fields are in a very low state of fertility. Wheat was planted on one of the fields in the fall of 1949. The crop was very poor. Brome grass seeded with the wheat had made such slow growth that in September of 1950 the soil was but very sparsely covered. For a year it had been practically bare. The fencerow was covered with a very dense bluegrass sod.

Mechanical analyses showed that the field and fence row soils were of identical texture—clay 10%, silt 35%, and sand 55%.

A close examination of the soil in the almost bare field showed that the surface was very compact. Readings made with a penetrometer (2) showed that the packed layer was about three inches deep. Below that depth the soil was relatively loose. Another compact layer existed at the seven-inch depth. Apparently a definite plow plan had developed. This is shown by the cropped soil curve presented in Figure 1. Note the contrasting curve obtained on the fence row soil. Each curve is an average of five recordings by the penetrometer.

The compaction in the cropped soil was the result of two forces, rainfall and gravitational settling at the surface, and the pressure from the plow and implement wheels at the furrow bottom. The organic matter and surface cover had prevented the compaction by the rainwater in the fence-row soil.

Several physical measurements were made on these two soils. Total pore space in the fence-row soil amounted to 59.8% as compared to 41.8% in the cropped soil. With the reduction in pore space, volume weight increased from 1.11 in the fence-row soil to 1.48 in the cropped soil.

Of even more importance than total pore space, perhaps, is the difference which exists in these soils in noncapillary pore space, 26.0% in the fence-row and 10.5% in the cropped soil. The small size of the pores in the cropped and packed soil results in slow air and water penetration. This was illustrated by measuring the rate of penetration of water through the cores of soil used in the pore space and volume weight measurements.

The cores were soaked in water for several days. They were then fitted with brass collars so a head of water could be held on the soil. The surface of the soil was covered with paper toweling to prevent disturbance of the soil. The core was then suspended and a record made of the time required for 100 ml. of water to percolate through the core of soil. All the water was poured on the soil at once. The data obtained on four cores from each soil are recorded in Table 2. The longest percolating time for the fence-row soil was 60 seconds as

Table 2. Percolation Through Fox Sandy Loam Cores

Core number	Time — 100 ml H_2O	
	Fence-row soil	Cropped soil
1	35 sec.	11 min.
2	45 sec.	24 min.
3	47 sec.	31 min.
4	60 sec.	95 min.

Table 3. The Clay, Silt, and Sand percentages in the Soils used in the Packing Tests

Soil	Clay	Silt	Sand
Brookston clay loam, cropped	30	28	42
Brookston clay loam, grassed	30	28	42
Hillsdale loam	13	43	44
Oshtemo sand	7	6	87
Coloma sand	6	12	82

compared to 95 minutes for the cropped soil. With such slow water penetration it is easy to understand why erosion may become so serious on sandy soils.

Pot Tests Illustrate Packing

To further illustrate the fact that sandy soils may become too firmly packed, several different soils were placed in ten-inch flower pots. Included were two clay loams, a loam and two sandy soils. The results of the mechanical analyses on these soils are presented in Table 3.

The pots of soil were partly submerged in water for several hours, or until the soils had become completely saturated. The pots were removed from the water and allowed to drain for a few minutes. The wet soils were then settled by thumping the pots lightly on the ground sixty times. They were then placed in an oven at 160°F. until thoroughly dry. The degree of compaction of the soil was determined with a penetrometer.

Most people believe that clay soils may be easily puddled but that the structure of sandy soils cannot be injured. The curves presented in Figures 2 and 3 show that they may be wrong in both assumptions. The curve for the grassed clay loam shows that the soil had *not* been puddled as only ten pounds of pressure was required to force a ½ inch pointed probe to the bottom of the pot. The soil granules were so stable that they had not broken down during the packing. The cropped clay loam, on the other hand, had become so hard that 160 pounds of pressure had resulted in less than one inch penetration.

Note now the curve for the loam soil. With as little as 13% clay this soil had become so thoroughly puddled

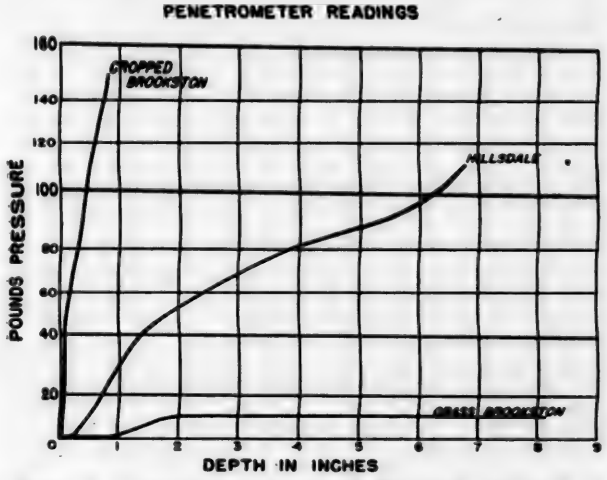


Figure 2. Compaction in a cropped Brookston clay loam as compared to a grass-land Brookston clay loam and a Hillsdale sandy loam. The measurements were made after the soils had been puddled and dried.

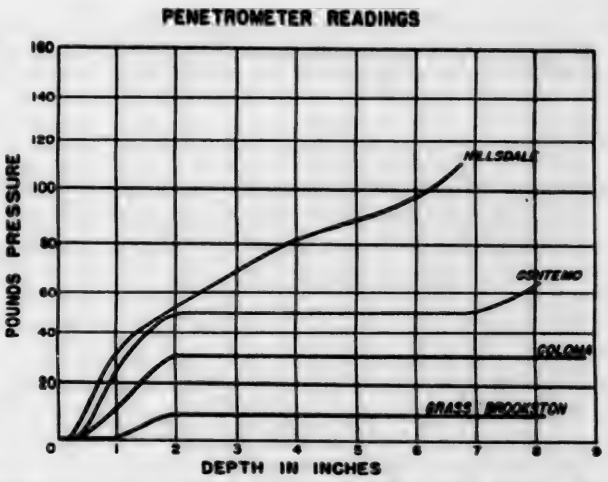


Figure 3. Compaction in grass-land Brookston clay loam, Hillsdale loam, Oshtemo sand, and Coloma sand. The measurements were made after the soils had been puddled and dried.

and hard that 100 pounds of pressure was required to push the penetrometer to the bottom of the pot. It had not packed so hard as the cropped clay loam, to be sure, but it was ten times as resistant as the grassed clay loam.

In Figure 3 the curves obtained from the two sandy soils are compared to those for the loam and grassed clay loam. Note that even the very light sandy soils packed harder than did the clay loam which was high in organic matter.

Discussion

Clay soils must be well granulated or they are very difficult to handle. Organic matter serves as a cementing material which holds the granules intact. The grassed clay loam contained such stable granules that they did not break down when an attempt was made to puddle the soil. Sand particles tend to weaken the soil granules. For that reason a *sandy* clay loam is less stable than a clay loam. As the percentage of sand is increased and the percentage of clay decreased, or as the size of the sand particles is increased a point is finally reached where large visible granules no longer form. One might say then that such soils "puddle" easily because there are no large stable granules to be broken down and thus the soil particles and small granules are free to crowd together and eliminate large, non-capillary pores.

This was well illustrated by the Hillsdale loam. Perhaps the figures are somewhat inaccurate as volume weight of a cultivated soil is rather difficult to measure but as nearly as could be determined, the packing reduced the volume sufficiently to raise the volume weight from 1.13 to 1.59.

If organic matter in a sandy soil does not serve as

(Continued on page 37)

Keeping the Dust Under Cover

F. L. DULEY

To prevent the return of another "dust bowl," says Professor Duley in this informative paper, we must establish on some 35 million acres conservation measures such as proper land use, strip cropping and stubble mulching, which have been found to be effective. If these fail, then emergency measures must be used. In addition, a program of continuous research for new control methods is of utmost importance. Research on the aerodynamics of wind, methods of practical control, new grasses, legume crops to supply nitrogen to support larger crops with heavier residues and others are some of the projects now in progress.

EVER SINCE MAN has cultivated his fields for the growing of crops he has encountered the movement of soil by the wind. With a rapidly increasing world population more land in regions of limited rainfall has been put under cultivation. In recent years wind erosion has been severe and caused extensive damage in Australia, Africa, China, the Near East, several countries in South America, Mexico, Canada and the United States. It therefore becomes one of the world's important agricultural problems. Farmers must be continually on guard against wind erosion, or its frequent recurrence will keep certain areas of the world on the verge of economic collapse. During the settlement and development of agriculture in the western half of the United States wind erosion has harassed the plains settlers at every turn.

Most of the Great Plains region of North America has been settled and put under cultivation during the last 80 years. Much of it has been broken out since the turn of the century and several million acres have been broken since the great stimulus given wheat production during the first World War. Another incentive to breaking sod came during and since World War II. The combination of favorable weather and the stimulus of high prices has encouraged farmers to break more range land for wheat production.

Periods of Dust Storms

During this period of agricultural development in the Great Plains there have been three periods of very severe dust storms. The first came during the drought period of the 1890's. This was a time before people had learned much about farming in regions of limited rainfall. They had tried to use Illinois and Ohio methods under the vastly different climatic conditions of the plains. Then came a period of more favorable climatic conditions.

This paper, by F. L. Duley, was presented at the annual meeting of the Soil Conservation Society of America held in Detroit, October 26-28. Mr. Duley is associated with the Soil Conservation Service in research, cooperating with the University of Nebraska.

However, about 1911 and the years following came another period of drought. It was at about this time that the ideas about capillary rise of water in soils, as a result of King's work in Wisconsin, had led to the development of the so-called "dust mulch" or "Campbell" theory of handling land under low rainfall conditions. Great Plains farmers had prepared their wheat land by keeping a dust mulch layer on the surface. When this period of drought came the land having this dust mulch was so vulnerable to the wind that the dust was picked up and blown out of the fields. The wheat plants present were badly damaged or killed by the dust. It was at this time that the Kansas station in work at the Colby Substation developed emergency methods of wind erosion control.

Control by Listing

The principles involved in these emergency measures were directly opposite to the idea of a dust mulch. That is, an effort was made to keep at least a part of the surface rough. Going through the field with a shovel cultivator lister or other tool that would throw up large clods from below the surface mulch was found to be effective in preventing soil movement. This method works best in soils that have a considerable amount of silt and clay, where the clods will last for a relatively long time. Sandy soils do not form very long-lasting clods.

Regrassing, Shelterbelts and Rotations

The worst period of dust storms came in the 1930's, after which another method has been widely recommended for wind erosion control, which is to seed the land to grass. This method seems always a safe one to suggest, for if land is seeded to grass and then not overgrazed it is a very effective method of wind erosion control. However, it was amply demonstrated during the 1930's that grass land can blow. Some range land was so badly damaged by wind that it was difficult to tell that it had been grass land. A considerable acreage, perhaps 2.5 million acres are being seeded to grass each

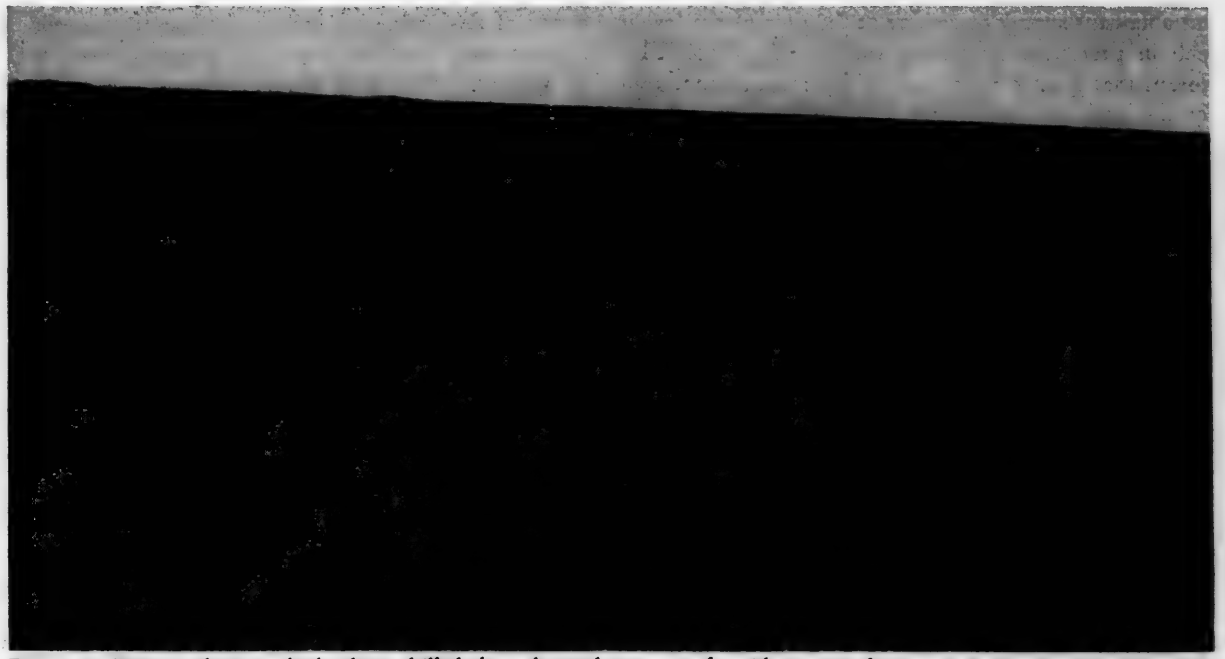


Figure 1. Winter wheat on high plains drilled through good amount of residue cover for protection against wind erosion.

year. The reasons we have not kept more of the plains in grass is because men have made too much quick money in wheat production. When men can break sod, put in wheat, and pay for the land in one year, it is difficult to convince the investor that he shouldn't do it.

Another method that has been widely publicized for protecting land against wind erosion is the use of tree shelterbelts. Many of these have done well, particularly on sandy soils in those areas where the soil is usually well supplied with moisture. On the drier and more exposed locations much more difficulty has been encountered. Up to the present time this method has had little overall effect in protecting the great broad wheat lands of the High Plains, because here fewer plantings have been made and the growth of trees is less rapid.

The introduction of different crops into the rotation is sometimes used to keep land covered. In some sandy areas, particularly in Nebraska and the Dakotas, corn has been followed with rye drilled in the corn, or by oats and then rye. This keeps a crop or crop residue on the land most of the time. If a legume like vetch can be introduced with rye, it will supply available nitrogen and add to the cover on the land. Cropping designed to protect land against wind erosion must be worked out to suit conditions in the locality concerned.

Stubble Mulch System

The most recent and probably the most effective method of protection for land against wind erosion is to provide a protective vegetative mulch cover at such times as the land would otherwise be bare. Of course cover afforded by a growing crop is most effective whenever the crop is large enough to give sufficient ground protection to keep movement of soil from starting. But this amount of protection may not be afforded by fall wheat at the end of a hard winter.

In lieu of a growing crop it has been found that the cover provided by the dead residue of the previous crop will go far in the reduction of erosion by wind. This method now widely known as the "stubble mulch" system is being used on an increasing acreage in regions where dust storms are most likely to occur. The latest report of the Chief of the Soil Conservation Service indicated about 20 million acres of stubble mulching in the soil conservation districts of the ten Great Plains states. In addition to this the idea has been widely used in Canada, and large areas in Saskatchewan and Alberta are farmed under this system, which they call "trashy fallow." The practice is also spreading in Australia and the Near East. The degree of control afforded by a stubble mulch system will depend on the density and evenness of distribution of the residue cover. If the cover is sufficiently dense and the straw not broken in too short pieces it will usually be partially covered with soil and anchored sufficiently to hold it against being blown out by the wind. If this condition prevails over the entire field it will withstand extended periods of high wind with a minimum of damage to the wheat crop. It cannot be too strongly emphasized, however, that there must be

an abundant supply of residue at the time of the lowest ebb in protection offered by the growing crop. This means that a large supply of residue must be produced on the land, and where land is fallowed this straw must be preserved on the surface in quantity, over a period of several months. There must be enough of it held over to do the job. A mere sprinkle of straw will not save a wheat crop from destruction under really severe dust storm conditions. If there is a good cover at seeding time and it is not buried by the drill it will probably hold through the winter because decay goes on more slowly during the winter season. In order to have these large quantities of straw we must learn through further research the most dependable methods of growing good crops with heavy residue regularly. Then after residue has been produced in quantity, it must be preserved with the utmost diligence in order that its capacity to protect the soil may not be lost before the time of greatest need for protection has arrived. This time of greatest need usually comes during the period February to April in the Great Plains. However, severe wind erosion may occur at other times.

Strip Cropping and Tillage Implements

As an added precaution another method has been introduced to hold down soil blowing. This is the practice of "strip cropping" or the growing of crops in strips across the prevailing winds, alternating with stubble mulch fallow. Wind erosion is most severe if it gets a long sweep over a smooth surface. Breaking the field into narrow strips which may vary with type of soil from 5 to 20 rods tends to stop soil movement in the next stubble strip before it gets a long sweep which would result in soil moving from the entire field. This method in itself, however, is not enough. Strip cropping should be combined with stubble mulching, and in some cases with more than one type of crop.

The thing many farmers in the Plains country need to learn is that when they once get a good cover of residue on the land they must make every effort to keep it there until another growing crop is well along. Great care must be exercised to prevent excessive burial of residue, which leads to a more rapid decay. Small grain stubble should be left attached to the ground as long as possible. Some of the tillage implements used in the Plains are to blame for exposing land to wind erosion. The one-way disk, which is probably the most widely used tillage implement in the Plains, may leave the land so finely pulverized and cover so much of the residue that the soil is exposed in a bare condition most vulnerable to high winds. This is particularly true if the one-way is used more than once during a fallow season.

Another implement that has recently come into use is a type of field cultivator having small narrow shovels or small sweeps. This leaves the land somewhat more cloddy and more corrugated than the one-way disk. However, if it is used too many times during a fallow period most of the residue will be covered and decay speeded up so that little protection may be left at seeding time.

In working out methods for preserving residue it has been found that a combination of tools is usually most satisfactory. When there are large quantities of straw the one-way disk, if properly adjusted, usually may be used to good advantage for the first operation in the spring to kill volunteer wheat and weeds on land that is being summer fallowed. It can be adjusted for shallow operation so that it will cover very little residue. This tillage operation should then be followed when necessary to control weeds with a machine having a broad sweep or the rod weeder that also will bury very little residue.

Danger of Another Dust Bowl

Many people ask the question as to the possibility of another "Dust Bowl." It is probably safe to say that we are annually in the position of being in danger of a "dust bowl." We can always expect high winds in early spring. If care is not taken in advance to protect the soil we may have severe wind erosion almost any year. During the last few years there have been numerous isolated spots, one year in Nebraska, next year in Oklahoma, and may be the next year in Montana.

In the central and southern Great Plains soil blowing was severe in the spring of 1950. Drought conditions have been a stark reminder of dustier days. Many farmers planted emergency crops of sorghum or sudan which should leave some residue on the land for protection against blowing in the spring of 1951. The use of approved soil and water conservation practices by many

Figure 2. Condition of soil after first working with one-way disk in fall. Very little residue has been covered. Left in this upright condition it will catch snow during winter.

farmers has done much to prevent the return of the old "Dust Bowl" conditions.

If we are to control wind erosion next spring we should have started last spring to get ready for it. Wind erosion control must start one year in advance. There must be no period of slackening of our efforts to hold dust in check. Dust moving from one farm onto another may start a dust storm that will spread for miles. Eternal vigilance by all the farmers in a region is the price we must pay for the control of dust storms. Community action is necessary if we are to bring the larger dust storms under control. New farmers in the area and the "suitcase" farmers are likely to risk seeding wheat on the sandier and shallower types of land. They give less attention to carrying out those practices which are most likely to pull them through with the least trouble from dust storms.

We have learned a great deal about methods that are effective in reducing the probability of serious wind erosion. Unfortunately these methods are still too poorly recognized and inadequately applied to make sure that the people in Detroit or New York may not be eating their "peck of dirt" from the wheat lands of western Nebraska, Kansas, or the Texas Panhandle. The favorable years during the 1940's have caused many to forget what happened in the 30's. Consequently they become lax in going to the trouble of taking precautions against dust storms when they haven't had a serious one for a year or two. Proper land use is a sound slogan throughout the Soil Conservation districts of America.

Research

Research is being conducted on practical methods of control, as well as the aerodynamics of wind erosion, but we need much additional study of this problem. More effective methods of control are undoubtedly possible. Further and more intensive research on this problem is urgent and should provide us with new weapons to combat this dust-storm menace. Methods of production that will insure more regularity in high yields of crops and consequently more residue for protection are greatly needed. New grasses adapted to various localities in the Plains are being developed. New methods may involve the whole question of controlling the available nitrogen supply and other nutrients, as well as making more efficient use of soil moisture. The Soil Conservation Service is conducting experiments on sandy soils in Nebraska where a legume crop to supply nitrogen to support larger crops with heavier residue seems the most logical first step in a system of wind erosion control. However, with the very inadequate funds and facilities for research on this subject, improvements are likely to come more slowly than would seem desirable. In the meantime we must make the best use possible of information now available. The best practices known must be carefully applied over the vast areas of the Great Plains and other regions subject to soil drifting. If this is done, and much is being done through the Soil Conservation districts, we can go far toward bringing wind erosion under control to a degree that we would not likely have a return of a "dust bowl" with such far-reaching consequences as was experienced in the Great Plains during the 1930's. To do this we must put into practice on some 35 million acres the methods such as proper cropping systems, regrassing, strip cropping and stubble mulching, which have been found to be effective precautionary measures. If, after all these things are carried out, dust still starts moving, emergency measures must be brought into play, as we would call the fire department for a fire. However, emergency methods cannot be expected to stop wind erosion in large fields after drifting has gotten well under way. If we are to have any real assurance against another "dust bowl," farmers must adopt as a regular system of management those soil and moisture control practices that will enable them to keep the soil under protective cover from one crop to the next.

Structure and Sandy Soils

(*Continued from page* 33)

a cementing material for large granules, what then is its role? Apparently it prevents the soil particles from settling together and serves to cement the clay and finer silt particles to each other and to the larger silt and sand particles so that soil capillaries are not filled up during the passage of water. Perhaps *small* granules really *are* formed. At least the fine particles are sufficiently stabilized that they are not readily moved by percolating water.

With such unquestionable evidence that sandy soils may become too firmly packed it seems that the entire problem of sandy soil management should be reconsidered. Perhaps heavy machinery can hurt a sandy as well as a heavy soil? Certainly the importance of soil cover and organic matter should be emphasized anew. Perhaps a new thought is that one of the roles of organic matter is to keep a sandy soil *loose*.

Summary

Certain fertilizer placement studies conducted on Hillsdale sandy loam showed that corn roots were slow to reach plowed under fertilizer because of the compaction of the soil after the land was plowed. The compaction was caused by rain and tillage.

In a comparison of cropped and fence-row sandy loam soil it was found that the fence-row soil, high in organic

(*Continued on page* 42)

Winter Aspects of Soil Structure

C. S. SLATER

All our observations, points out Mr. Slater, indicate that we have not been paying enough attention to what happens to the soil during the winter months. Cover crops have been used to reclaim lost nutrients or as a source of organic matter. More recently, however, we have thought of them as erosion controls. But I believe, continues Mr. Slater in this paper, cover crops should be considered as having insulating value to prevent damage to the soil by freezing and thawing.

WHEN EROSION IS NOT a major factor, loss of structure in tilled soil is associated mainly with clean-cultivated crops and a concurrent decomposition loss of soil organic matter. Now it happens that clean-cultivated crops are grown usually during the summer months, when high temperatures in conjunction with adequate moisture favor a rapid decomposition of organic matter. It is small wonder then, that loss of structure has been associated with the summer season, even though the period of clean tillage is ordinarily less than 100 days. What happens to soil structure during the remainder of the year? More precisely, what happens during the winter months as opposed to the summer season?

One thing that happens in most of these United States is that the soil freezes. It doesn't freeze very hard or deep in the South; it tends to freeze and stay frozen in the North. In between, there is a wide belt where freezing and thawing of moist soil is apt to occur repeatedly.

I hope that you have had an opportunity to observe seasonal changes in soil conditions in this intermediate belt. You will have noted, I am sure, that frost doesn't go as deep, soil doesn't freeze and thaw as frequently, under mulch and heavy vegetation as it does on summer-cropped land that is left bare over winter. You will have noted that a granular condition of the soil exists in sod and under mulch that is not typical of land that was left bare over winter. In contrast, the bare and unprotected soil often will appear to be slumped and puddled. When it dries out, it tends to become brick-like, and in certain soils shrinkage cracks will form.

It is quite probable that many of the granules or aggregates in the protected soil will be identifiable as worm casts, and earthworm counts generally will show the presence of a much higher population in the protected soil. Moisture conditions also are apt to be different in soils with and without protection. Insulative protection, or the lack of it, changes the amount of heat that is radiated from the surface soil and sets up entirely different microclimates in it. When we attempt to examine the effects of winter cover crops or mulches on the physical properties of the soil, we face a complex of changed conditions where it is not a simple matter to determine casual relationships.

Figure 1. Did frost do this? The plowed plot in the background has been bare over winter for the past three winters. Note how the soil has run together under the influence of spring rains. Compare this condition to the granular quality of the clump of soil in the foreground that has had winter protection for the past three winters. Over summer, the soil in the background slumped to a volume-weight of 1.53. The plot represented by the clump in the foreground maintained a volume-weight of 1.31.

The complexity of the soil factors that are operative during the winter months are no doubt responsible for the confused opinions that are current regarding the field effects of freezing and thawing on soil structure. (1). The most specific effect is loss of water-stability. This is a physical property of soils that is measured by determining the relative resistance to disintegration of soil aggregates when they are exposed to the slaking action of water. It is an important physical property, for if soils of moderate or heavy texture are lacking in water-stability, they slump and puddle when exposed

C. S. Slater is Project Supervisor in Research, Soil Conservation Service, United States Department of Agriculture. His headquarters are at Beltsville, Maryland. This paper was presented by Mr. Cook at the annual meeting of the Soil Conservation Society of America held in Detroit, October 26-28, 1950.

to saturating rain, and quickly lose any tilth that may have been imparted to them by tillage.

The decrease in water-stability that is caused by freezing and thawing appears to be governed by the moisture content of the soil, and the number of times the cycle is repeated (2). The damage is most severe when soils are frozen and thawed at high moisture contents. However, under field conditions when freezing and thawing occurs repeatedly, the soil need not be above field capacity initially to suffer severe damage. Each successive cycle draws water to the zone where freezing takes place. Freezing may occur finally under conditions that approach saturation.

On bare soil where the action of frost has been severe, effects of freezing and thawing are readily observable in the spring, before the land is plowed and harrowed, in the puddled, or compacted and structureless condition of the soil. After the land is tilled, these readily observed effects are apt to disappear. Then it is difficult to see that any deterioration of structure has taken place, and testing of the soil is necessary to determine if residual effects remain. Tests show that the water-stability is not changed by tillage and the deteriorating action of frost carries over to the tilled soil. The effect on crops has been indicated by growing sudan grass in tubs of soil under controlled conditions. Freezing and thawing appeared to lower the productivity of soil. Unfortunately, the same type of test has not been devised for plot testing. Under field conditions, the specific effects on crop production of soil freezing and thawing are inextricably mixed with other effects of the cover crops or mulches that might be used to minimize frost damage to soil structure. However, crop yields are increased by rotations in common use that reduce the frequency of barren and unprotected winter soil conditions.

Freezing and thawing also affects the erodibility of soils. There is a close relation between erodibility and the water-stability of soil aggregates. Soils of low water-stability are subject to high runoff because they puddle and seal more easily at the surface. Accelerated erosion is of frequent occurrence in early spring when soil is found in a dispersed condition from the combined action of frost and water. Spring oats following corn in a rotation have allowed more erosion in some areas than has the corn crop itself. Why? Remember that the oat crop followed a winter when the land itself was unprotected from whatever vicissitudes of freezing and thawing that the climate was able to offer.

At College Park, Maryland, we kept track of seasonal changes in soil structure that took place on field plots over a period of two years. We made measurements of water-stability, infiltration rates and pore space on the silt loam soil of these plots and found that the deterioration in structure that occurs when land is plowed out of sod takes place in two phases. When sod land is plowed and planted to a clean-cultivated crop, there is first a moderate decline in soil structure that can be measured in the lowered water-stability of the soil aggregates. This occurs, probably, because of the decomposition of fibrous roots of grasses that reenforce the structural aggregates mechanically, and so increase their water-stability under sod. We considered this loss of water-stability to be the first phase of structural decline. Plowing actually increased the infiltration rate and the porosity of the soil. These measurements were still at a high level in the fall of the year, after a summer of clean cultivation.

Of course, winter began in earnest sooner or later, with enough rain to bring the soil up to field capacity, accompanied by freezing and thawing of the soil. It was then that the second phase of structural decline could be observed and measured. Slumping of the unprotected soil took place with a corresponding decrease in porosity and water intake. Water-stability decreased with successive freezings and thawings and reached its lowest level in early spring. Later spring and summer were periods of partial structural recovery. The water-stability of the soil increased, but its compacted condition remained unchanged until the land was plowed again.

We made measurements of seasonal changes in soil structure on plots in winter wheat, continuous corn and continuous sod, as well as on plots that were plowed out of sod. We made tests on mulched areas. Everywhere, we found a consistent story. Deterioration of structure during the winter months is related inversely to the amount of insulative protection on the soil. Decline is increased by high moisture and free water and the severity of alternate freezing and thawing.

All of our observations indicate that we haven't been paying enough attention to what happens to soil during the winter months. It's true that we have peddled the idea of winter cover crops, but we have thought of them as scavenger crops planted to reclaim nutrients that might otherwise be lost by leaching, or as sources of organic matter to be plowed under in the spring. More recently, we have thought of them as erosion controls. But, I believe it is a new idea to consider them as having insulation value to prevent damage to the soil by freezing and thawing. From this standpoint, a prostrate or matted crop or mulch that traps air and radiant heat close to the ground surface would have more value than the same quantity of an erect growing crop that leaves much of the ground exposed. This new idea brings up other questions. How valuable are late planted winter cover crops that offer but little winter protection? Shouldn't cover crops be planned to give a heavy fall

Figure 2. What frost does to soil. The tub on the left was protected from freezing and thawing over winter by an inch of straw mulch on the surface. Note that the soil is within two inches of the top of the tub. The tub on the right was left bare over winter. Note that the soil has slumped to a point four inches from the top of the tub.

and winter ground cover? How much winter protection is necessary? Are mulches feasible? What about spring versus fall plowing? I do not know the answers to these questions, but I shall consider them hereafter with more understanding than I have been able to give them in the past.

We were fortunate when we made our studies on structure at College Park because the two winters covered in our study happened to be quite different as far as freezing and thawing were concerned. The winter of 1947-48 caused considerable freezing and thawing of the soil, and in contrast, the winter of 1948-49 was exceptionally mild. There was very little freezing and thawing of the soil during the latter winter. The difference in winters was reflected in what happened to unprotected soil. The soil didn't change very much under sod in either winter, but on land left bare after corn in the summer of 1947, water-stabilities dropped over winter from an average value of 43% to an average of 19%. In the second and milder winter that followed, even the bare land maintained a high fraction of its water-stability. Its stability was 44% in the fall—it dropped only to 42% by early spring.

Now we are faced with an important question. If winter deterioration in soil structure were prevented, would the seasonal increases in water-stability that occurred during the summer months becomes cumulative? To answer this question, we seemed to have a situation made to order. We had had a winter when there wasn't any structural deterioration worth mentioning. All we had to do was to continue our measurements through another autumn and see if the new fall values for water-stability so obtained exceeded the corresponding previous values that were obtained on these plots. That is exactly what happened. On the continuous corn plots, the seasonal increases in water-stability that occurred during the spring and summer resulted in fall values of 43 and 49 per cent, respectively, for the years 1947 and 1948, but in the fall of 1949, when the mildness of the previous winter had prevented the usual winter decline, water-stability values rose to 58%. These results were typical of other continuous corn plots that were manured each spring. On the manured series the fall values for water-stability were, respectively, 41, 40 and 56%. In winter wheat after corn, fall values of 46 and 43% in 1947 and 1948 increased to 65% in the fall of 1949.

Similar data that were taken on plots in timothy and red clover after winter wheat are particularly interesting. The water-stability values of 68 and 71 per cent that characterized these plots in the falls of 1947 and 1948 reflect a structural improvement (in comparison with the continuous corn plots or the plots in winter wheat after corn) that is related to their cover of grass and legumes. This higher level did not prevent a further improvement in structure when winter deterioration was eliminated. In the fall of 1949, the water-stability on these plots rose to 81%. This value approaches what appears to be a maximum water-stability for the soil when judged by the water-stability levels that characterized plots in continuous sod. Inclusive of seasonal variation, the range in water-stability on the sod plots from the fall of 1947 to the fall of 1949 was from 80 to 88 per cent.

The data that we obtained seem to leave but little doubt that the prevention of structural deterioration on

(Continued on page 42)

Recent Research Reviews

JAMES H. STALLINGS

Streambank Erosion Control on the Winooski River, Vermont. *By* FRANK C. EDMINSTER, WALTER S. ATKINSON *and* ARTHUR C. MCINTYRE; *USDA Cir. No. 837. October 1949.*

This circular gives the case history of streambank erosion control and flood-plain protection on the Winooski River, Vermont. Like scores of other streams in the Northeast, the Winooski has cut away its banks. It has overrun its channel. It has taken short cuts or long meanders across farm fields. It has staged destructive floods. The authors give an account of the measures used to curb the destructive erosion of this stream. These included vegetative and mechanical measures, separately and in combination. Both successful and unsuccessful efforts are described. Finally, those measures and structures that proved most successful in checking erosion and flood damage are briefly summarized.

Will This Soil Drain? *By* C. H. M. VAN BAVEL; *What's New in Crops and Soils, Vol. 2, No. 7, pp. 10-11. April-May 1950.*

The author describes a method which anyone may use to determine the permeability of the soil, which will serve as a guide to tell whether or not a soil can be drained and, if so, how well it will drain.

A hole is dug four feet deep with an eight-inch post-hole digger in soil which has the water table within 12 inches or less from the surface in the spring. As soon as the water rises to its normal water table height in the hole pump or dip it out as rapidly as possible. Before removing the water from the hole place a peg exactly one foot below the surface of the water. Observe the length of time necessary for the water to rise to the marker. The permeability of the soil can then be read from a prepared table.

Adaptation of Grasses to Soil and Water Conservation at High Altitudes. *By* R. H. STARK, A. L. HAFENRICHTER, *and* W. A. MOSS; *Agron. Jour., Vol. 42, No. 3, pp. 124-127. March 1950.*

The results reported in this paper deal with adaptation and organic matter production by grass on very fine sandy soil at high altitudes in eastern Idaho. The soil is subject to severe water and wind erosion when cultivated in a wheat-fallow system. Eleven grass species, representing five use groups, were tested on land that had been farmed for approximately 26 years. The wheat-fallow system of farming previously used had caused 50 percent reduction in the soil organic matter.

Within six years big bluegrass, pubescent wheatgrass, smooth bromegrass, Fairway crested wheatgrass, and intermediate wheatgrass restored soil organic matter to levels that were not significantly different from the organic matter content of the virgin soil.

Radioactive Materials as Plant Stimulants—Field Results. *By* LYLE T. ALEXANDER; *Agron. Jour., Vol. 42, No. 5, pp. 252-255. May 1950.*

This report contains the results of field tests conducted during the 1948 and 1949 crop seasons to determine if radioactive materials stimulate plant growth. The general conclusion is that no effect of the radioactive materials was found, either beneficial or harmful.

Some Factors Affecting Humus Development in the Northeast. *By* RICHHARD S. SARTZ *and* WILLIAM D. HUTLINGER; *Jour. of Forestry, Vol. 48, No. 5, pp. 341-344. May 1950.*

Some of the important factors affecting the development of forest humus layers in the northeast have been brought to light during the course of flood-control survey investigations being made in the northeast. Evidence has shown that the depth of humus increases with the age of stand until maximum foliage production is reached, and that humus depth is directly correlated with stand density. Although age is largely the expression of total organic matter accumulation, density (which is a measure of the amount of foliage) controls the balance between organic accumulation and decomposition. Logging fire and grazing have destructive effects on humus layers, depending on their intensity and frequency or duration. Evidence was found that northeast slopes develop deeper humus layers than other aspects and that micro-topographic features caused extreme variations in humus depths. In addition, inconclusive evidence showed that less humus is likely to develop on sandy soils than on heavier-textured soils, other factors being equal.

A Review of Evaporation Theory and Development of Instrumentation. *By* E. R. ANDERSON, L. J. ANDERSON *and* J. J. MARCIANO; *U. S. Navy Electronics Laboratory, San Diego, California. NE 121215, Report 159, Problem 2jla. February 1950.*

The purpose of this report is to review all evaporation equations based on the mass-transfer and energy-budget approaches, and to describe the instrumentation, devel-

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The Reviews by J. H. Stallings that follow are a regular feature in the JOURNAL. It is hoped that the projects reviewed from time to time will be helpful to conservationists everywhere. Members of the Society are urged to indicate their interest in the kind of research work that should be reviewed.

oped and modified for experimental testing selected equations. The review of existing theory is believed to be complete as of August 1, 1949. As regards the choice of equations, the aim is to test as many as appear to have a reasonable possibility of success, consistent with limitations on manpower and finances.

Measuring Water in Irrigation Channels with Parshall Flumes and Small Weirs. *By* R. L. PARSHALL; *USDA, SCS Cir. No. 843. May 1950.*

This circular describes practical measuring devices for the beneficial and economical use of irrigation supplies. Standard weirs of various types and sizes are discussed. Their advantages and disadvantages, and recommendations for their use are set out. The merits of the Parshall measuring flume are also explained. This device has been perfected in sizes ranging from throat widths of three inches, which can accurately measure flows of 0.1 second-foot as a minimum, to that of structures having throat widths of 40 feet with a maximum capacity of more than 2,000 second-feet. Flumes as here described range in size from three inches to eight feet and are limited in capacity to about 100 second-feet.

A Direct Method of Computing and Correcting the Equivalent Depth of Water in a Soil Column. *By* JAMES O. HENRIE; *Agr. Eng., Vol. 31, No. 6, pp. 290-291. June 1950.*

The author presents a direct method of computing the equivalent depth of water in a column of soil when sampled with the improved King soil-sampling tube, or any other sampling device that cuts a circular core out of the soil. He also describes a correction to be used with this sampling method to correct for a gain or loss of core. This is a fast and accurate means of computing the inches of water in a soil sample after the actual sampling has been done.

Rainfall Interception by Chaparral in California. *By* E. L. HAMILTON *and* P. B. ROWE; *Calif. Dept. of Nat. Resources. 1949.*

The authors present the results of three rainfall interception studies conducted in shrubby vegetation native to California. They show that much of the rainfall caught by this vegetation, and generally assumed to be lost by evaporation, actually reaches the ground by flowing down the stems. Equally important for practical application of the results, the studies demonstrated that the amount of interception loss in this vegetation bears a definite relation to the amount of storm rainfall. Once this relation has been established for a given type of vegetation, the interception loss can be readily determined from rainfall measurements alone.

Structure and Sandy Soils

(*Continued from page* 37)

matter, did not pack and did allow rapid percolation of water. The cropped soil was found to be very compact at the surface and at plow depth. It did not allow rapid water percolation.

Several soils were compacted by jaring the pots in which they were contained while the soils were saturated with water. The soils were then dried and tested for compaction with a penetrometer. A cropped clay loam was too hard to penetrate with 160 pounds pressure on a ½ inch pointed probe. A virgin clay loam of identical type and texture was penetrated by a force equal to ten pounds. A loam soil containing only 13% clay was ten times as hard as was the virgin clay loam. Two sandy soils were also packed harder than was this same virgin clay loam, even though the clay loam contained 30% clay.

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Winter Aspects of Soil Structure

(*Continued from page* 40)

cultivated lands during the winter months can be an important factor in the maintenance of good physical conditions in the soil. More investigations are needed to determine how important it is under varied climatic and soil conditions, but there are, unquestionably, large areas where high winter moisture in conjunction with freezing and thawing cause a breakdown of soil structure on land that does not have an insulative winter protection. On these areas, the winters that follow clean-cultivated crops as well as the crops themselves must be considered in planning crop rotations and land management practices to conserve the physical quality of the soil. Mulches and winter crops that cover the ground will help, and there are other possibilities to be investigated in connection with winter surface drainage.

Recognition of the problem of winter decline of soil structure is imperative. Solving it will go a long way, I am sure, toward that desirable state of affairs when our agronomic practices result in gradual improvement, rather than gradual deterioration, of soil structure.

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BOOK REVIEWS

BIG HUGH. The Father of Soil Conservation. *By* WELLINGTON BRINK. *With a preface by* LOUIS BROMFIELD. *167 pages. Frontispiece. 1951. New York: The Macmillan Company. $2.75.*

Here is a biography long overdue, masterfully written by the one person best equipped to chronicle the life of Hugh Hammond Bennett, the dynamic Chief of the Soil Conservation Service. As Editor of SOIL CONSERVATION Magazine, Wellington Brink has been long and closely associated with the man he calls *Big Hugh.*

There have been Who's Who outlines, magazine sketches, fragments taken out of context, but never before has there been made available a full, coordinated, satisfying record of the life of the father of the far-flung soil conservation movement. *"Big Hugh,"* therefore, constitutes *big news* indeed!

From the first terrifying realistic paragraphs, picturing the scorched and suffering Dust Bowl of 1935, to the last chapter, with its message of hope and warning, *"Big Hugh"* is an absorbing, fast-moving, inspiring account of a tremendous agricultural leader, of his amazing discoveries, his struggles and aspirations and accomplishments.

Read the first few paragraphs and there will be no laying it aside until you have finished the book.

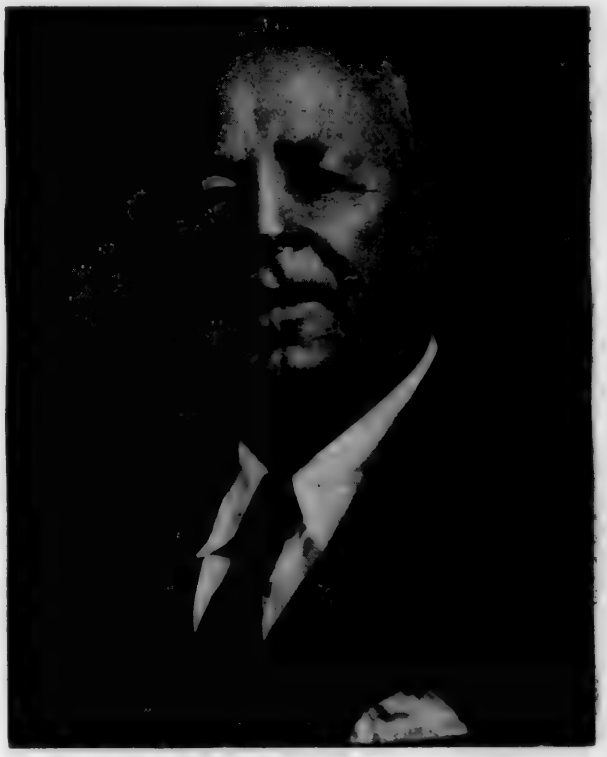
"The land burned and smarted and cringed in agony of drought and wind and dust," Brink writes, and goes on to relate the dramatic events which led to the passage of *"the first soil conservation act in the history of this or any other nation."*

Bennett's preparation for his role of emancipator of the exploited soil of this earth began in childhood on the family plantation in the Piedmont section of North Carolina. It was there that at the age of ten he first had insight into the ravages of erosion. It was there that he acquired his lusty enjoyment of food, learned to endure hardships, to surmount disappointments, developed his robust constitution and his amazing tenacity of purpose.

"Hugh Bennett is a consequence of land and people. Heredity and environment, the hard discipline of post-bellum days and the low workings of geologic time all had a part in producing this man of soil," says the author.

Brink's narrative combines seriousness and comedy, with colorful depictions of the family and their life, leaving a lasting imprint of a rugged but satisfying boyhood.

"On graduation from the university in 1903, Hugh Bennett looked out on a broad tableland of opportunity. His was a wide latitude of possible careers for which he had aptitude and a considerable groundwork of experience."



Big Hugh, the founder of the Soil Conservation Society of America and the father of Soil Conservation.

Yet he chose a position in the Bureau of Soils, U. S. Department of Agriculture, surveying soils, a job which "fitted him like a pair of old shoes." It was in this work that he learned the soils of this nation "to an extent approached by no other man before or since."

With almost three-dimensional clarity, Brink recounts the hardships of the ensuing months and years when the young scientist "lived with sun and rain and wind and fog, with snow and ice and mud—and the people along the way."

And then he adds—"Winter firesides yielded a valuable postgraduate course. Hugh picked up a lot of honest, grass-roots rural knowledge that helped him get off on the right road."

It was knowledge that stood him in good stead years later when he helped to formulate the down-to-earth soil conservation district plan.

Alerted to the erosion problem, Bennett came to have one purpose in life—to free the soil from human bond-

age, for the benefit of all mankind. He continued his surveys, reporting conclusions as well as facts, only to have them go unnoticed.

It was a discouraging business. But the persistent young scientist went on accumulating evidence to support his claims.

"At last, after 25 years of hanging on and fighting on and piling up his case, Bennett obtained official recognition of the gravity of the erosion problem when the Department of Agriculture published his "Soil Erosion, a National Menace.'" This was "the first great victory . . . that rallied the beginnings of the forces that were to build steadily toward a national program of soil conservation."

Brink takes you with Bennett on his travels through the Western Hemisphere, brings to sharp focus the character and attributes of the man who, in his lifetime, has built up an accumulating legend as "a sort of benign demigod."

You see him taking advantage of every possible means at hand to get the newest and best information on land treatment directly to the people as quickly as possible. You see him inspiring unswerving loyalties, practicing rigid economies to enlarge the scope of the work.

This is no chronological recording of the events of Bennett's life, and therein lies part of the book's fascination.

Events, experiences, and accumluated knowledge all led eventually to the plan which slowly evolved, the model soil conservation districts act. This plan is now being copied, sometimes with modifications to fit the circumstances, by nations the world over.

Brink pin-points Bennett not only as the national and international leader of the soil conservation movement, but also as perhaps the one man who has found a way to preserve the democratic American way of life, and as an unofficial ambassador of good will in this tumultous world. Ultimately this may become of greater importance even than his contribution to agriculture.

Bennett has made history. The growth of the movement has been spectacular. Honors have been heaped upon him. But he is not content to rest on his accomplishments or laurels, Brink points out. Though he will reach retirement age next spring, he visions ever-widening fields to study, new problems to meet and solve. As the pace grows increasingly faster, his loyal co-workers in the Soil Conservation Service are spurred to higher and higher goals and reach them sooner than anticipated.

Workers of other agencies are working harmoniously now with Service personnel for the common good of the country. But "the popular status of soil conservation makes it an inviting, almost irresistible, target for a considerable entente of evil-wishers," Brink warns in the concluding paragraphs. These are men who would wreck the movement consciously or unconsciously.

"But, today, as a hungry world gropes for survival, we can ill afford to risk foolishness or ineptitude or short-cuts or substitutes," he cautions.

If you would know The Chief in person, if you would renew your faith in the traditional American freedoms, initiative, and independence, if you would find hope for the future, don't neglect to read this book. It is as faithful and exciting a piece of historical writing as will come your way in many a long day. It is as important to urban cliff dwellers as for men and women of the land.

—MARGARET SUHR REED, *Cleveland, Ohio*

IRRIGATED SOILS: Their Fertility and Management. *By* D. W. THORNE *and* H. B. PETERSON. *The Blakiston Company, Philadelphia, Penna. 74 Illustrations; 288 pp. $5.00.*

"Irrigated Soils" by Thorne and Peterson of Utah State College is a book dealing with the problems encountered on irrigated soils on lands in the western part of the United States. Its up-to-date information, its readability and its stress on the business of protecting the valuable western soils, make it a book that everyone dealing with irrigated lands should own. It is both a textbook and a book of value to an experienced irrigationist.

The book is divided into 25 chapters, each of which covers a particular phase of the subject. The reader is first invited to review, with the authors, the world-wide picture of irrigation. From this point on they describe the nature of irrigated soils. Considerable space is properly devoted to the latest findings regarding saline and alkali problems and their relationship to land, plants and water. The findings of the U. S. Salinity Laboratory are fully drawn upon. Several chapters are devoted to land evaluation, quality of water, water rights, and the business of applying water. From there on they move swiftly into irrigation practices and their affect on soil, drainage, erosion and crop production.

The importance of maintaining and improving soil properties gets a lot of attention under chapters devoted to physical and biological properties of the soil, with a chapter devoted to maintaining organic matter. The last eight chapters are devoted to fertilizers and special problems for various crops. The last chapter is unique, I think, in a book of this type. It is called "Soil Management Around the Home."

The wealth of references, the up-to-dateness of the data, the excellent bibliography and the glossary stamp this as a book that can be relied upon.

If the 288 pages of the book had been extended to 325 pages and more data included under the chapter

on "Drainage" and "Field Application of Water," the book fould come very close to being the sole reference book needed by the irrigationist, who is engaged in the task of getting water effectively and efficiently applied to the land.

—Fred H. Larson, *Portland, Oregon*

CONSERVING SOIL RESOURCES: A Guide to Better Living. *Compiled and edited by* Paul W. Chapman, Frank W. Fitch, Jr., *and* Curry Lafayette Veatch. *Turner E. Smith & Co., Atlanta, Ga. 1950. xiii + 355 pp. Illustrated with color plates, halftones, and figures.*

Teachers, particularly those in urban schools, confronted with the necessity of teaching soil conservation are often at a loss to find vital subject matter, interestingly and attractively presented. The soil and its problems are often pretty far outside the experience of apartment-house dwellers. Students in rural areas are sometimes strangely ignorant of, and indifferent to, soil and water conservation. The present volume seems admirably suited to arousing interest of teachers and students alike.

This volume is one of a series on conservation subjects issued by the Turner E. Smith Company. Others in the series are *Conservation of American Resources,* by Elliott; *Pastures,* by Lancaster, Bailey, James, and Harris; and *Southern Forestry,* by Mobley and Elliott. Like these related books, the present one is well written, logically organized, and handsomely illustrated. It is suitable as a text for high school and junior college courses, and it will be valuable as supplementary reading in biology, agriculture, geography, and the social sciences.

Chapter titles will be indicative of the contents. They include *Land and People, What Is Soil?, Soil and Water Problems, How Farm Lands Become Impoverished, Our Soil Conservation Program, Saving and Enriching Farm Lands, Land and Wildlife, Conserving Nonfarm Lands, Does Conservation Farming Pay?,* and *Response of the Good Earth.* Each chapter is organized as a unit for more effective teaching. There is a useful glossary of conservation terms, and a well-selected bibliography.

Most of the chapter units are introduced by color plates. Each one is summarized, and there is a suggested list of activities in connection with each. As in other volumes in this series, there are significant quotes from conservation writers. Thus the reader may become acquainted with some of the best thought of leaders in the conservation field. The concluding chapter represents conservation on the high level of a crusading cause.

One of my colleagues, after looking through this book, remarked that its effectiveness would depend on having teachers to present it who are well grounded in, and thorough converts to, the conservation viewpoint. This comment would, I take it, apply to the presentation of any textbook material; nevertheless, it does serve to point up the need of trained teachers of conservation. While much is being accomplished in conservation education, it still remains lamentably true that most teachers have met conservation concepts on but few occasions during their formal training. *Conserving Soil Resources* can do much toward broadening the teacher's own understanding, and should make it easier for any student to realize his dependence on, and to make his adjustments to, the Good Earth.

—Maurice Brooks, *Morgantown, West Virginia*

TREE CROPS—A Permanent Agriculture. *By* J. Russell Smith. *The Devin-Adair Company, New York. 408 pp. $6.00.*

This book is of vital importance to every adult citizen in the country. To those interested in conservation of natural resources, patricularly soil and water, it is a *must.* The first edition of *Tree Crops* was published in 1929. During the years since then Mr. Smith, through the knowledge and experience gained by his own endeavors and those of others, has completely revised the first edition, adding a wealth of new information and notes. The result is that it reads like a new book. It is amply filled with illustrations which, in themselves, tell a graphic story of the world-wide problem and its possible solution. *Tree Crops* has been selected as the "Book of the Season" by the Friends of the Land.

In starting out Mr. Smith leads the reader on an extensive world-wide trip to distant places such as the Great Wall of China, to Syria, Greece, Italy, Guatemala, Corsica, Palestine and many others, leading back to the United States and then to each of the individual states. During this brief extensive tour the consequences of neglect of soil and water conservation of the country are vividly depicted. Where civilizations once existed, naught but desolation now occurs in many places. The moral is clearly brought out that unless public consciousness is awakened to the seriousness resulting from waste of soil and water resources, the future of our own prosperous nation will become blacker and blacker leading, as Mr. Smith puts it, to a "quick descent into economic Hades."

After painting this picture, Mr. Smith then points to the way out. He shows the need for using trees, particularly those which supply food for man and animals on hilly and steep areas in place of the annual crops such as cereals and grasses which require the use of the plow and other cultivating implements. The author points to places where, as a result of necessity, certain European and other countries have resorted to this practice, producing food in sufficient quantities to support entire

villages, in places where absolute desolation would have prevailed long before this if the flat land type of agriculture had been used.

A plan is proposed, embodied around an *"institute of mountain agriculture."* These institutes would be variable in size and the amount of work which could be undertaken in them. It is explained that one man with a few acres could do a tremendous amount of work, and in areas of several thousand acres, maintained by business, philanthropic, and governmental agencies, much more could be produced. As Mr. Smith explains it, "Such an institute would have a variety of work to do:

1. Finding parent trees from which to start crops;
2. Hybridizing to produce better parent trees;
3. Maintaining testing grounds to try out the new trees as trees—testing them by ten thousands to find the good *trees.*
4. Operating experimental farms to try out the new *trees* as *crops.*
5. Making studies in *farm management.*
6. Carrying on publicity work to get the new idea into the conservation mind."

These points are expanded and the way is clearly pointed out how such institutes could function and how each individual could help in advancing the work.

The subject matter has been presented in four parts: *Part One,* "The Philosophy" presents the basic idea of adapting tree crops to hill lands, steep and rocky places, and to lands where rainfall is deficient.

Part Two, "Some Facts About Some Crop Trees to Suggest Some of the Possibilities That Lie in This Proposed Work" presents a variety of facts and subjects pointing out the inestimable value to the United States and other countries following the proposals outlined by Mr. Smith.

Part Three, "Economics, Farm Applications, and National Applications" explains how present crop trees and others which might be discovered or created could be used in the economics of the individual farm and how this might involve the national wealth and stability of the country and civilization.

Part Four, "Who Will Do the Basic Scientific Work Which This Book Calls For?" A resume is given of those who are now working in line with the principles advocated by Mr. Smith and the hopes for the future.

A large portion of the book is devoted to technical as well as interesting facts concerning specific crop trees, some of which are now used for food trees and others which could be improved and used as a supply of food for both man and animals. These are dealt with in considerable detail. The following are some of the species thus treated: Shagbark hickory, shellbark hickory, pecan hickory, butternut, black walnut, Chinese walnut, chestnut, Chinese and American persimmon, and their natural hybrids. These are among those which produce food for humans. In addition such trees as the acorn producing oaks, honey locust, chestnut, persimmon, mulberry and many others can be used to increase food production for animals. All of these can be grown profitably in some portions of the United States.

In the concluding chapter Mr. Smith indicates "The Great Hope and the Many Little Hopes." The Great Hope is an endowed foundation. Among the Many Little Hopes, Mr. Smith exhorts, are "fellow citizens of small means, such as the farmers, lawyers, manufacturers, doctors, teachers, spinsters, villagers, who are the members of the Northern Nut Growers' Association, and others like you: don't wait for the Government to do it. It may help, but probably can't do the longdistance stuff. Don't wait for the millionaire. There is room for him when he comes and also for you, too, and right now. Have you an intellect? Or just a kind of high-animal brain? Do you know the thrill of creative work? Of learning or creating something really new?

"Use your imagination constructively. An *idea, a small yard* and one tree may be made to produce astounding results."

One can not read this book through without feeling a strong urge to do something about the problems presented. The book is recommended to every adult American. One answer to your nation's future security lies in its covers.

—EDWARD M. SIMMONS, *Upper Darby, Penna.*

WATER AND MAN. A Study in Ecology. *Compiled and edited by* JONATHAN FORMAN *and* OLLIE E. FINK, *Friends of the Land, Columbus, Ohio. 1950. 407 pp. ill., $4.50.*

This compendium on the importance of water, its place in the human ecology, and a survey of current problems and possible solutions in its use and conservation is probably unique in the field of conservation literature.

An all-star cast of authorities and publicists contributed their several viewpoints to the work. They treat the theme from many angles—that of the engineer, the hydrologist, forester, soil scientist, ecologist, economist, and public administrator. Whatever each may have individually to say about water, one thing is certain—they are all "for it"; all emphasize its importance as a national resource, and the urgency of an effective conservation program.

The tone of the book is well summarized by the legend on the fly-leaf: *"Water . . . Why pray for it? Why not save what the Lord gives us?"*

The subtitle, *"A Study in Ecology,"* is inept. The separate articles lack the integration needed to bring the ecology of the subject well into focus. The trained ecologist will find little new information here, and the untrained will not discover the meaning of ecology.

Rather, the book will be of most interest and use to readers of the middle ground—neither professional technicians nor uninformed laymen, but those already familiar with the topic of conservation. It will quicken their enthusiasm for the movement and provide much usable material for the ever-growing crusade for public and private action in this endeavor. Doubtless, this was the aim of the publishers, a society devoted to *"the conservation of soil, man, and rain."* The book is a summary of the proceedings of the Eighth Annual Conference on Conservation, Nutrition, and Health.

—BEN OSBORN, *San Angelo, Texas*

REPORT TO THE ONTARIO LEGISLATURE
from the Select Committee on Conservation. 188 pages and XXI introductory pages, profusely illustrated with black and white and color illustrations, and 11 maps. Toronto, 1950. $1.00.

In April of 1949, the Ontario legislature resolved to appoint a select committee to study all aspects of conservation. A year later, in March 1950, the committee made its report, and a very full and interesting one it is. The report is comprehensive, well organized, very well illustrated, and contains a summary of recommendations placed in the beginning. Any state in the United States could profit by this example from Canada, and be proud of such a job.

The Canadian constitution vests control and administration of natural resources in the Provincial government, and it is clear from the report that Ontario intends to discharge this responsibility. Of great importance is the proposal to centralize the leadership of the conservation program in the Department of the Prime Minister. The report adds that "it would do much to assure success if the Prime Minister himself accepted leadership in relation to overall policy." Further, the report recommends a Deputy Minister who would be a Chief of Conservation, and as such would coordinate the conservation activities of all interested Departments and agencies of the Provincial government. This would be comparable to setting up a lieutenant-governor in our states with a similar function.

The report covers a wide variety of problems and makes a total of 84 specific proposals. A large number of these deal with proposed expansions or increases in activities already going on, and with the initiation of new work. Proposed changes in legislation are numerous, and will possibly require considerable time to effect.

The recommendations provide for acceleration of soil surveys, for setting up demonstration farms, and expanding soil erosion research and extension work. Enlargement of farm drainage services and research are envisioned, and considerable improvement of municipal drainage. There is provision for coordinating all the various agricultural services supplied by the colleges into one educational institution under a President and three deans. At the same time, there would be a stepping-up of extension activities and services. Long-term credit for young farmers is provided for, and an enlightened policy of agricultural settlement in northern Ontario.

In the field of waters, flood control activities would be somewhat enlarged, municipal water supplies would be improved, especially by ground-water and other source surveys; and the work of existing Conservation Authorities broadened and increased. Farm ponds, small dams, and lakeshore erosion are all given added attention.

Forestry activities are proposed that would expand considerably the fine work already going on in Ontario, and similarly work is proposed on fish and wildlife, recreation, education, and weed control.

It is heartening to see that the committee is recommending action on all fronts, not just a few, and certainly not in a piecemeal fashion. One has the feeling that here is a *whole* program, designed to deal with *all* aspects of conservation.

The program recommended is ambitious and far-reaching, although this reviewer could not find a farmer mechanism suggested that could make the program go at the grass roots. The report itself notes (p. 71) that in the United States, "it was not until machinery was established whereby the farmer, or groups of farmers acting together, could take the initiative in improving agriculture, that real progress was achieved." This is an allusion to the soil conservation district, and the report is correct in its statement. However despite the fact that "there is already much evidence that this initiative exists on the part of Ontario farmers who have been requesting land use advisory services," it seems reasonable to point out that until there is one kind of enabling machinery set up enabling farmers to organize for action, the finest program can still fail.

Authorship of the report is not given, of course, but someone on the committee can really write:—

"Soil," says the report, "is not just the material on which we build buildings, it is the stuff of which empires are made!"

"Would it not be better to think of our Province as being so many inches deep rather than so many square miles in area?"

"Soil, as we see it . . . . represents the future at our feet."

Copies of this report are available through the Office of the King's Printer, Parliament Buildings, Toronto. They are priced at one dollar per copy and are well worth it. A brief review of this kind cannot portray the excellent treatment of the matter, but it can be said that soil conservationists in the United States would do well to purchase copies for their personal libraries.

—WILLIAM R. VAN DERSAL, *Portland, Oregon*

FARM AND GRASS SEED MANUAL. *By The J. Chas. McCullough Seed Company, Cincinnati, Ohio. Compiled by Wm. E. Ward, Second Edition 1950, 148 pages, $1.00.*

This manual treats fifteen species of pasture grasses with twenty common pasture weeds; sixteen species of turf grasses with eight weeds; fourteen species of legumes, and seven species of forage crops grown in the North Central states, specifically the Ohio Valley. They are illustrated by line drawings and a brief account is given of each concerning its history, description, adaptation, culture and uses. Photographs are interspersed to create interest and add clarity to the text. The plates on weed seeds call attention to impurities which can be removed with good equipment and experienced help. Agricultural workers will find sections on "Establishing and Maintaining a Good Turf" and "Common Turf Pests" helpful in dealing with this problem. The concluding section contains such useful information as a planting chart giving the rate, date and depth of seeding for the species treated in the manual; what is an acre of pasture worth to a good farm boy; why use pasture mixtures; regular American weights and measures; a list of Agricultural Experiment Stations, and two pages of "Reference Literature."

The author has succeeded in making this a Manual and not a seed catalog. The subject is well treated, except the discussion on 2,4-D which should be brought up to date in the light of recent discoveries.

—A. D. STOESZ, *Lincoln, Nebraska*

WATER, LAND AND PEOPLE. *By* BERNARD FRANK *and* ANTHONY NETBOY. *Alfred A. Knopf, New York. 1950. 331 Pages. $4.00.*

This book is in brief an inventory of conditions brought about by man's tamperings with nature's balance across the lands of the United States. Moreover, this treatise places a gauge or measuring stick against the use and misuse of renewable natural resources inherent in our political and economic system of the country. Upon this basis, much logic is portrayed in an evaluation of the exploitation as well as the reconstruction, reclamation and conservation of these resources leading the reader to arrive at a mental balance sheet of resource use and damage.

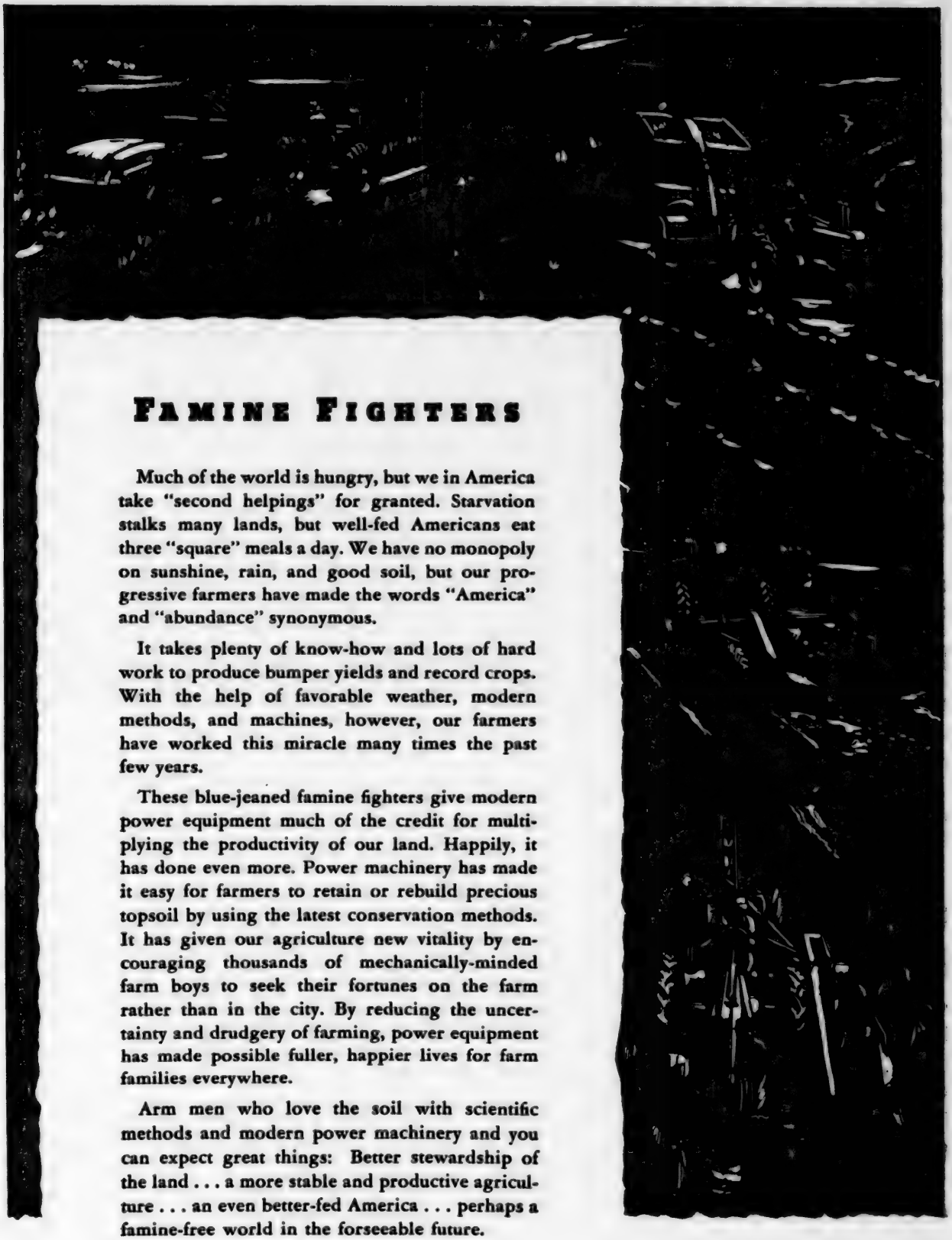
The evidence cited leads an informed student of natural resources to but one conclusion—grandiose utilization or corrective projects, whether they be in the nature of flood control, forest conservation or complete land and water use, are failures if disregard for protection on every minute parcel of geographic area is not included. A national roundup of well-described land conditions indicates that all the unified forces of nature within the proximity of the spot where precipitation falls is the only safe place to begin a permanent conservation and resource use activity. In this regard the small watershed tributaries at the top of a great system becomes the primary unit on which effort and expenditures should begin. Unified and coordinated treatment and management of small watersheds in the minds of the authors would seem to minimize the problems that have been so common to the lower basin projects previously undertaken on several of our larger river basins.

The more than three hundred pages are packed with striking examples that would cause the student of natural resources to recount and relate his own experiences and observations, locality by locality, wherever he may have worked and lived. To such a student or technician who moves about, the book would serve well as a guide to what to look for in delving deeper into the effects of malpractice as well as conservation and wise resource use progress. In this connection the book would be especially valuable to the forester and water engineer.

On the whole, the horrible paradox of too much water at a given place and time, or too little water at the same place at another time, is the picture painted by this book. It would seem, however, that the research done by the authors reveals that sufficient experience, knowledge and technical sense exists or could be acquired in unified natural resource planning to begin to make real progress toward the elimination of such situations as, the race between damaging floods and water famine; reforestation and forest destruction; game surpluses and game shortages; gullied hillsides and waterlogged bottom lands.

The problem then becomes one of how man with his complex system of industry, commerce, and society in general, can continue his use of renewable natural resources at an ever-increasing rate without the further disruption of the ecological balance and possible complete devastation and eventual destruction.

The parts of the book given over to "land use solutions" throw some very interesting light on how renewable natural resources may be permanently productive



FAMINE FIGHTERS

Much of the world is hungry, but we in America take "second helpings" for granted. Starvation stalks many lands, but well-fed Americans eat three "square" meals a day. We have no monopoly on sunshine, rain, and good soil, but our progressive farmers have made the words "America" and "abundance" synonymous.

It takes plenty of know-how and lots of hard work to produce bumper yields and record crops. With the help of favorable weather, modern methods, and machines, however, our farmers have worked this miracle many times the past few years.

These blue-jeaned famine fighters give modern power equipment much of the credit for multiplying the productivity of our land. Happily, it has done even more. Power machinery has made it easy for farmers to retain or rebuild precious topsoil by using the latest conservation methods. It has given our agriculture new vitality by encouraging thousands of mechanically-minded farm boys to seek their fortunes on the farm rather than in the city. By reducing the uncertainty and drudgery of farming, power equipment has made possible fuller, happier lives for farm families everywhere.

Arm men who love the soil with scientific methods and modern power machinery and you can expect great things: Better stewardship of the land . . . a more stable and productive agriculture . . . an even better-fed America . . . perhaps a famine-free world in the forseeable future.

JOHN DEERE

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and intensively used. Even so, the complete answer will not be found in the proposals of the authors, but if the principles set out will be recognized as the beginning point, some real progress will be made. One of the better examples of an integrated plan of action toward desired progress is the brief history of what has happened in the Muskingum Water Conservancy District in Ohio. This area covering more than five million acres, occupying approximately a fifth of the state of Ohio, has received the finest type of cooperation between federal and state governments, local agencies, land owners, and land and water users in a unified and integrated soil, forest, wild life, recreation and flood control development program. The important aspect of the Muskingum project is that the guidance of the work is from within the area and not from without.

The chapters on major river valleys should be read with all the other fundamentals in the preceding parts of the book in mind in order to appreciate that adequate natural resource development programs should be relieved of many of the political aspects now involved in present broadscale proposals. The long-term physical, biological and economic aspects of any resource development activity become more important to me, at least, after reading WATER, LAND AND PEOPLE—"the dramatic picture of our growing water famines and floods, the human consequences, and the possible remedies"—by Bernard Frank and Anthony Netboy.

—LLOYD E. PARTAIN, *Philadelphia, Penna.*

AMERICA'S NEW FRONTIER, THE MOUNTAIN WEST. *By* MORRIS E. GARNSEY, *University of Colorado. Alfred A. Knopf, New York. 1950.*

Mr. Garnsey's book, *America's New Frontier, the Mountain West,* is an analysis of the mountain west by an economics professor in a western university who has a reputation for insight, acumen, and originality. He analyzes the social, economic, and political characteristics of the mountain west in the light of the past, present, and probable future trends. The central theme is that the mountain west is at the junction of its destiny now and events of the immediate future will determine which way it will go: whether it will develop a balanced economy of its own, or whether it will continue to be a source of raw materials for more advanced areas.

Conservation questions are very much involved, and come in for much discussion. Garnsey suggests a twelve-point program which the west may follow and arrive at a balanced economy, and at least seven out of his twelve points are primarily conservation considerations.

Garnsey makes several points of conservation importance. One is that the "real hope of effective development of Western resources lies in the adoption of the administrative device of the regional authority." This is by all odds certainly true. The closely integrated nature of the various phases of land use, industry, recreation, and city development, and the complex patterns of land ownership, the racial and ethnic composition, the fact that there is great shortage of water in relation to the claims, and the correlated peculiar problems of extra-basin use of water strongly support this view. Certainly a farm-by-farm approach to conservation will not succeed in the west. Rather, an approach which would bring the whole economy into balance with land use capabilities is indicated.

In my opinion—based purely on observation in various parts of the west—Garnsey's apparent optimism that conservation has become "visible and tangible to nearly every citizen of the west" is an overly sanguine statement. (I wonder if he really feels this way.) "Conservation" and especially "stock reduction" are fighting words when mentioned before practically every stockman with whom I have come into contact, and sadly enough the same is true of many irrigation farmers and business men, and the words often are greeted by a cold and icy stare in the eyes of such professional people as school administrators, depending, of course, upon the degree to which the "cold war" between the stockmen and the Forest Service has affected the particular communities.

Garnsey presents an excellent but brief analysis of this "cold war." I think conservationists should be much more out-spoken in opposing the destructive influence the stockmen's "Protective Associations" have had. There has not only been harassment and rank persecution of well-qualified and fair-minded individuals—Forest Service employees—but there has been intimidation of others who dared indicate support of them. This sore spot in western affairs ought to be more drastically treated; it is one of the most destructive factors delaying conservation progress as well as economic progress. The centers of such treatment will have to be in the larger and more industrialized communities.

The book implies that there is needed a thorough reorientation of the western mind—away from the range livestock business as the western economic element deserving most consideration and toward industrialization with management and labor exercising greater influence.

Any person desiring a better understanding of the economic and political environment in which conservation must operate in the west should read Mr. Garnsey's book.

—PAUL PHILLIPS, *Grand Junction, Colorado*

(Continued on page 56)

Pattern for a Brighter Future

Thousands of our farms have a new look these days. The patchwork pattern of square fields, that invites erosion, is giving away to a new soil-saving design. More and more of our crops are growing in swirling strips and flowing contours that hug precious topsoil to sloping land.

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A special IH task force is tackling erosion control and other tough farm problems. We call this section of our company Farm Practice Research. Here are some of the things this group of farm specialists is doing:

1. **Studying soil and water conservation problems**
2. **Research in soil analysis and land rebuilding**
3. **Research in methods of applying fertilizer**
4. **Research in handling new field crops**
5. **Studying land use trends**

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FIELD NOTES AND COMMENTS

Barriers to Conservation Practices Being Studied

Barriers in the pathway of application of conservation practices on the land is the subject of studies recently initiated at the Harvard School of Public Administration and the School of Law of the University of Pittsburgh, according to the joint announcement made by Fairfield Osborn, president of the Conservation Foundation, Dean Edward S. Mason of Harvard and Dean Charles B. Nutting, head of the University of Pittsburgh School of Law. The Conservation Foundation has sponsored both programs and has raised the funds to carry them out.

The Harvard project will take the form of a graduate seminar the objectives of which will be to identify the major obstacles now preventing widespread use of known conservation techniques on the soils, forests, grazing lands and water sources of the United States and how to overcome such obstacles within the accepted principles of the free enterprise system. The course represents the first attempt to define the proper contributions of both private and governmental agencies at all levels.

At the University of Pittsburgh work will consist of a review and analysis of all statutes and administrative regulations dealing with conservation in the State of Pennsylvania, as well as a study of organization, coordination and practice in administration.

It is hoped and expected that reports of the work at both Harvard University and the University of Pittsburgh will be ready for publication in the autumn of 1951.

Educators from Three States Attend Conservation Conference

College teachers of Minnesota, Wisconsin, and Illinois expressed a need for closer working relationship with soil conservation agencies in the area of preparing future leaders and teachers. The conference was planned as a result of this interest. The program was built around the idea of promoting and developing conservation education through the exchange of ideas and to acquaint teachers with recent developments in the conservation field. A committee representing Minnesota, Wisconsin, and Illinois planned the initial conference which was held at La Crosse, Wisconsin, on August 28-30, 1950, with 30 educators in attendance.

The program started with a challenging address by Dr. C. H. Bailey, Dean of the College of Agriculture, University of Minnesota, on "The Responsibility of Educators in the Soil Conservation Program." This was followed by a tour of the Soil Conservation Experiment Station. The evening was devoted to a round table discussion of "The Problems in Teaching Soil Conservation," with a panel representing the colleges and universities of the three states.

The second morning was devoted to a discussion of "What Should be Emphasized in Teaching Soil Conservation?" Papers were presented by Dr. Emil Truog, University of Wisconsin; Professor P. W. Manson, University of Minnesota, and William DeYoung, Soil Conservation Service, Wisconsin. The afternoon was spent on a neighboring farm and a study of "The Farm as a Laboratory for Teaching Soil Conservation."

The session was concluded on the third day with presentations by B. F. Rusy, Executive Secretary, Wisconsin State Soil Conservation Committee; F. J. Schmeeckle, Chairman, Conservation Education Department, Central Wisconsin State Teachers College, and Miss Betty Herold, a rural school teacher of La Crosse County. Their respective papers were "Sources of Information and General Organization of the Soil Conservation Program;" "How to Train Teachers to Teach Soil Conservation," and "How I Taught Soil Conservation in a Rural School."

The conference was a success and the group participating completed plans to continue a similar program in Illinois in 1951.

—I. O. Hembre and Orville E. Hays,
La Crosse, Wisconsin.

MD/M, a Measure of Monthly Rainfall Distribution Is Urged

There is a tendency to use average monthly rainfall alone as an adequate description of the climatic water supply. This note is an argument for an additional measure, the variability or distribution about the average. The two measures, average and distribution, permit two dimensional thinking concerning monthly rainfall.

Monthly rainfall distribution varies from approximately "normal" to highly skewed, with many more occurrences below the average than above it. The standard deviation can be used to describe normal distributions but not highly skewed ones. The percent average miss can be used to describe skewed distributions. This measure is technically the ratio between (1) the mean deviation from the mean and (2) the mean, with the point of origin at 0. The abbreviation MD/M is suggested.

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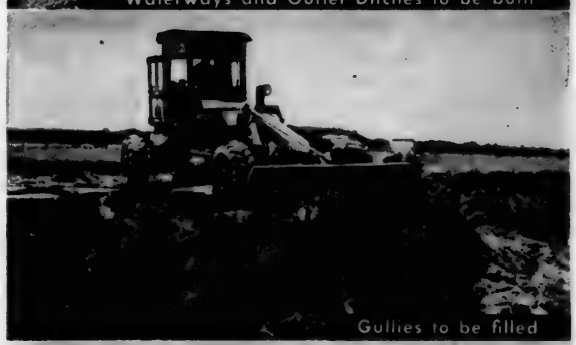
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SINCE 1859

Photos by Soil Conservation Service

Pictorial Study of Snow Ridging. Two ways to ridge snow to help prevent its blowing away are shown in the photographs above. The upper right picture shows some of the snow ridging that was done in North Dakota. This picture was taken February 7, 1950, a day after the ridging with an angle bulldozer blade. The snow ridges were 30 to 32 inches high and the distance between ridges 20 to 30 feet. The lower right view, taken a month and a half later, shows unridged land adjoining the ridged area to the right. Note that the unridged area is practically bare, but much snow still remains on the area where ridging had been done. *Keeping the snow on the land is a moisture conservation measure.*

—ELMER WORTHINGTON and WILLARD KUNKEL, *Bottineau, North Dakota.*

A low MD/M of .25 to .30 indicates approximately "normal" distribution of monthly rainfall. A high MD/M of .65 to .75 indicates a highly skewed or one-sided distribution with more occurrences below average than above. An intermediate MD/M of .45 to .50 indicates a moderately skewed distribution.

$(MD/M)^2$ is a good estimate of the probability of monthly rainfall in the Southeastern United States being one-half average or less. For the low MD/M's, this would be .06 to .09 or less than 1 in 10. For the high, it would be .42 to .56, about 1 in 2.

$(MD/M)^4$ is a reasonably good estimate of the probability of monthly rainfall in the Southeastern United States, being twice average or more.

$\frac{1}{2}[1-(MD/M)^2 - (MD/M)^4]$ is a reasonably good estimate of the probability of monthly rainfall being $\frac{1}{2}$ to 1 average and also 1 to 2 average.

At Jacksonville, Fla., the average monthly rainfall for August is 6.27 inches and for November 2.05 inches. Without additional information, one would assume most of the monthly rainfalls would be near the average. The MD/M for monthly August rainfalls is .30 and for November .66. These indicate August rainfall distribution approximately normal, but the November rainfall highly skewed. Most monthly rainfalls in August will be near the average. A high per cent, $(.66)^2$, of monthly rainfalls for November will be $\frac{1}{2}$ average or less, and a moderate percent, $(.66)^4$, twice average or more, leaving a small percent near the average. November at Jacksonville, Fla., is drier than the average monthly rainfall indicates. At this station, the monthly rainfall MD/M remains moderately high during the remaining winter months then increases to .61 for April and declines to the low .30's for July and August. The high monthly MD/M's are associated with long periods of drought; the low with either short or no periods of drought.

—PAUL TABOR, *Spartanburg, South Carolina.*

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The mysterious strength-multiplying power of hydraulic controls is clearly explained by this latest of Case visual education materials. It is simple enough for youngsters to grasp, yet it keeps their fathers interested through 30 vivid minutes of field scenes and animated drawings. A profusely illustrated 16-page take-home booklet clinches what the film teaches. Booklet has a section on hydrostatics especially helpful to students. Read below how to get free use of this new film for your class or club.

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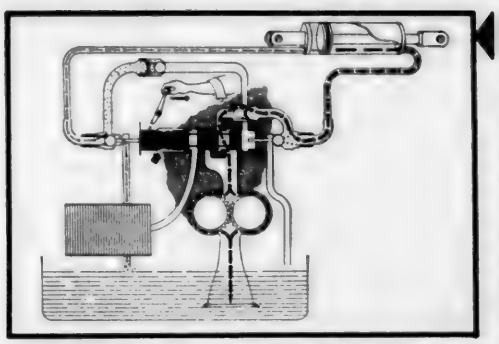
By action scenes with a dozen or more implements and machines, "Hydraulic Controls" teaches vital lessons in conservation farming, in saving labor, time, and farming costs. Disk harrows are angled and de-angled on-the-go, sparing grass in waterways and on headlands. Both mounted and pull-behind implements get fair shares of attention. Function of the portable hydraulic cylinder and piston is demonstrated, as is the interchangeability of ASAE standard cylinders.



HOW THEY WORK

Animated mechanical drawings show valves as they open and close; the pump pumps and oil flows; the hydraulic piston moves in or out at the will of the driver. Thus, in clear pictures and plain language, the student sees and hears the complexities of hydraulics simplified. The companion booklet of the same title can be studied at home or in class.

Case Visual Education Materials. Case offers a wide and valuable selection of sound-slide films, 16-mm. movies in sound and color, booklets, wall charts and posters—all at no charge. They are useful in teaching soil and water conservation and the best in modern farm methods. Send now for free booklet, "Case Visual Education Materials." It lists and describes each, tells how to schedule films and order printed matter. Address Racine office.

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Films are loaned and booklets provided without charge to agricultural leaders and appropriate groups—county agents, extension workers, vocational agriculture teachers, civic and farm clubs. Schedule this movie through your nearest Case dealer or branch, or write to Educational Division, J. I. Case Co., Racine, Wis.

Book Reviews

(*Continued from page 50*)

Irrigation Principles and Practices. *By* ORSON W. ISRAELSEN. *John Wiley and Sons, Inc. 1950. 405 pages. $6.00.*

This important book was written to meet the needs of college and university students, seeking information in the fundamental aspects of irrigation principles and practices. It features a simplification of the flow of water in the soil, drainage of irrigated lands, the consumptive use of water and the social and administrative phases of irrigation. The sketches, photographs, examples illustrating the applications of basic equations of hydraulics are all excellent. The author also includes much information that is important in the economic use of water in irrigation.

Soil conservationists, county agents, irrigation farmers and others will also find the book valuable for reference purposes in the development and perpetuation of arid-region agriculture.

Deciduous Forests of Eastern America. *By* E. LUCY BRAUN. *The Blakiston Company, Philadelphia. 596 pp. 1950. $10.00.*

This book, because of the material it contains regarding original forest conditions, is useful for soil conservationists and plant ecologists. It is divided into three parts: composition of virgin forests, formation of deciduous forests and the evolution of the present pattern of forest distribution.

The author spent 15 years and traveled 65,000 miles studying these original forest patterns, many of which are no longer in existence. The book, therefore, will also be useful for college courses in conservation of natural resources, ecology and forestry.

The Trees of Pennsylvania. *By* WILLIAM C. GRIMM. *Stackpole and Heck, Inc., Harrisburg, Pennsylvania. 363 pp. Illustrated. $5.00.*

This unusual book is primarily for persons interested in trees, not professionally, but as living things. It contains full page drawings leaves, twigs, flowers and fruit of the many species described. Although limited to Pennsylvania, with a few exceptions it could easily include the entire northeastern United States.

In addition to the information about growth, habitats and distribution of trees, the book also answers many questions such as these: What trees provide good deer browse? What is the favorite food tree of the beaver? What happened to the Chestnut?

Weeds — Guardians of the Soil. *By* JOSEPH A. COCANNOUER. *The Devin-Adair Company, New York 10, N. Y. 178 pp. 1950. $2.75.*

The function of this book as pointed out in the Publisher's Preface "is to demonstrate how the controlled use of weeds can be sound ecology, good conservation and a boon to the average farmer or gardener." It is probably the first book to be written in praise of weeds. The author tells how weeds restore eroded land; also how their vigorous root systems bring up mineral elements from the subsoil. It is written in an informal style and should be read by persons working with the soil.

The Pursuit of Plenty. *By* A. G. MEZERIK. *Harper & Brothers, New York. 1950. 209 pages. $2.50.*

Moisture Requirements in Agriculture Farm Irrigation. *By* HARRY BURGESS ROE. *The McGraw-Hill Book Company, New York. 413 pages. 1950. $5.50.*

Vertical Farm Diversification. *By* D. HOWARD DOANE. *University of Oklahoma Press, Norman. 184 pages. $2.75. 1950.*

Forest Terminology—*A Glossary of Technical Terms Used in Forestry. Society of American Foresters, Washington, D. C.*

New Conservation Film

The Soil Is Good. *Color with Sound. Running Length 40 Minutes. Minneapolis-Moline Company, Minneapolis 1, Minnesota.*

This film stresses the importance of the soil to mankind and to the welfare of the nation. It points out what the soil has done to help man and what unfortunately is happening to the soil in too many areas. It emphasizes what can be done to safeguard the soil and to prevent appalling losses due to erosion by wind and water, water pollution, insect infestation, and careless soil management. It touches on such soil conservation practices as contour farming, terracing, strip farming, crop rotation, cover crops, flood control, land reclamation, and shelter belts. The film also includes colorful sequences showing how modern machinery is helping the farmer carry out such soil conservation practices so that he can save his soil, increase his yields, and reduce his production costs.

Correction Statement

In the article "*A System of Soil-Profile Characterization*" by Smith and Samuels in the October issue of the JOURNAL, the "greater than" (>) and "less than" (<) symbols were inadvertently omitted at a number of places in Table 3. The reader should supply these symbols as logically required wherever single numbers instead of ranges are given in the columns. Also, under the "Total bases" column in Table 3, page 163, the bottom number should be 50,000 instead of 5,000.

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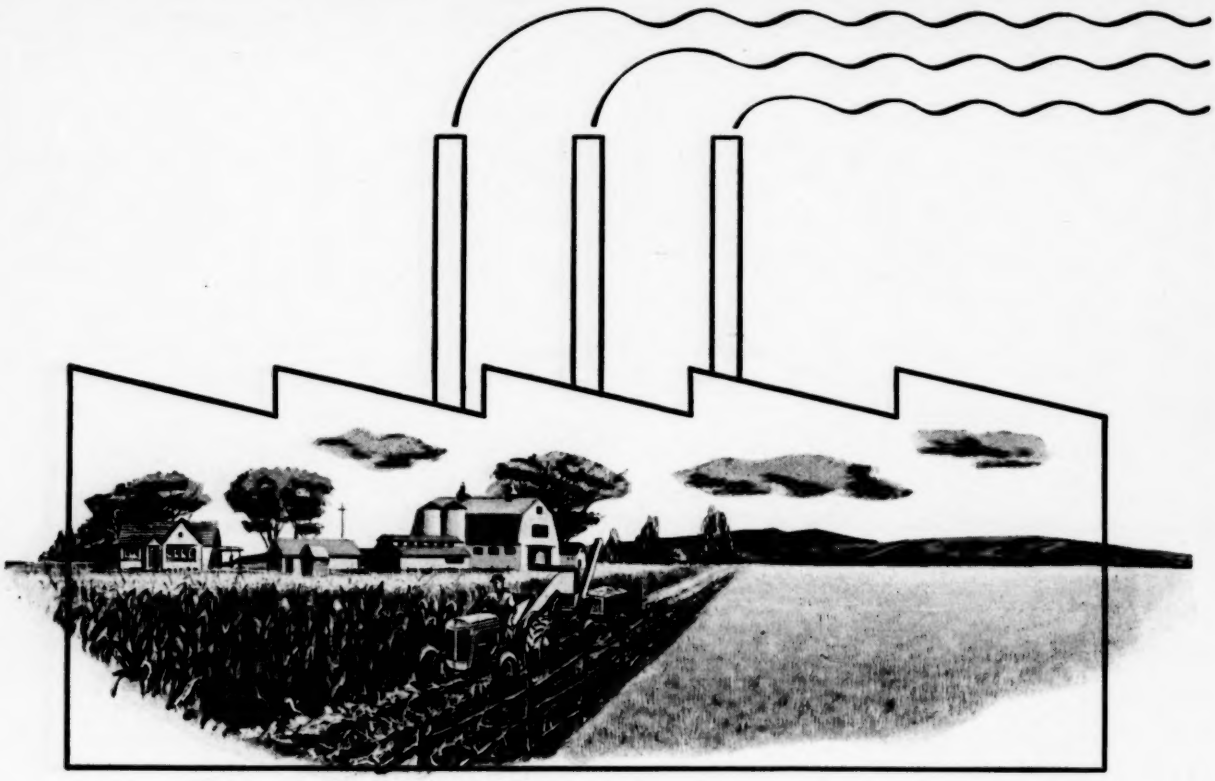

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